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Direct/Delayed Response Project: Quality Assurance Plan for Preparation and Analysis of Soils from the Mid-Appalachian Region of the United States

Lockheed Engineering and Sciences Co., Inc., Las Vegas, NV

Prepared for:

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M.L. Papp, R.D. Van Remortel, C.J. Palmer, G.E. Byers, B.A. Schumacher, R.L. Slagle, J.E. Teberg, M.J. Miah

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The Direct/Delayed Response Project is designed to address the concern over potential acidification of surface waters by atmospheric sulfur deposition within the United States. The Mid-Appalachian Soil Survey is being conducted as a synoptic physical and chemical survey to characterize a statistical sampling of watersheds in a region of the United States believed to be susceptible to the effects of acidic deposition. The survey has benefitted from information gained during two previous, similar surveys. This documentation addresses the design and implementation of a quality assurance program and the verification of the analytical data base for the Mid-Appalachian Soil Survey. It is addressed primarily to the users of the data base who will be analyzing the data and making various assessments and conclusions relating to the effects of acidic deposition on the soils of the Mid-Appalachian region, the third and final region characterized during the project.

Data quality is assessed by addressing detectability, precision, accuracy, representativeness, completeness, and comparability of the data.

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DIRECT/DELAYED RESPONSE PROJECT: QUALITY ASSURANCE PLAN FOR PREPARATION AND ANALYSIS OF SOILS FROM THE MID-APPALACHIAN REGION OF THE UNITED STATES

by

M.L. Papp , R.D. Van Remortel, C.J. Palmer, G.E. Byers,
B.A. Schumacher, R.L. Slagle, J.E. Teberg, and M.J. Miah

A Contribution to the
National Acid Precipitation Assessment Program

Aquatic Effects Research Program

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Environmental Research Laboratory, Corvallis, Oregon 97333

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This document is one volume of a set which fully describes the Direct/Delayed Response Project, Mid-Appalachian Soil Survey. The complete document set includes the major data report, quality assurance plan, laboratory analysis handbook, field and laboratory operations reports, and quality assurance reports. Similar sets are being produced for each Aquatic Effects Research Program component project. Colored covers, artwork, and the use of the project name in the document title serve to identify each companion document set.

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[1] Lockheed Engineering & Sciences Company, Las Vegas, Nevada 89119.
[2] Environmental Research Center, University of Nevada, Las Vegas, Nevada 89114.

Abstract

The Direct/Delayed Response Project is designed to address the concern over potential acidification of surface waters by atmospheric sulfur deposition within the United States. The Mid-Appalachian Soil Survey is being conducted as a synoptic physical and chemical survey to characterize a statistical sampling of watersheds in a region of the United States believed to be susceptible to the effects of acidic deposition. The survey has benefitted from information gained during two previous, similar surveys. This document addresses the design and implementation of a quality assurance program and the verification of the analytical data base for the Mid-Appalachian Soil Survey. It is addressed primarily to the users of the data base who will be analyzing the data and making various assessments and conclusions relating to the effects of acidic deposition on the soils of the Mid-Appalachian region, the third and final region characterized during the project.

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List of Abbreviations

AA	atomic absorption spectrometry
AC_BACL	barium chloride triethanolamine exchangeable acidity
AD	analytical duplicate
AERP	Aquatic Effects Research Program
AL_AO	acid oxalate extractable aluminum
AL_CD	citrate dithionite extractable aluminum
AL_CL	exchangeable aluminum in unbuffered ammonium chloride
AL_CL2	aluminum in 0.002M calcium chloride
AL_PYP	pyrophosphate extractable aluminum
ALSOW	analytical laboratory statement of work
ANOVA	analysis of variance
BD_CLD	clod bulk density
BD_KV	known volume bulk density
CA_CL	exchangeable calcium in unbuffered ammonium chloride
CA_CL2	calcium in 0.002M calcium chloride
CA_OAC	exchangeable calcium in buffered ammonium acetate
CEC	cation exchange capacity
CEC_CL	unbuffered ammonium chloride cation exchange capacity
CEC_OAC	buffered ammonium acetate cation exchange capacity
CLAY	total clay fraction
CLP	Contract Laboratory Program
CRDL	contract-required detection limit
DDRP	Direct/Delayed Response Project
DL-QCCS	detection limit quality control check sample
DQO	data quality objective
EMSL-LV	Environmental Monitoring Systems Laboratory at Las Vegas, Nevada
EPA	U.S. Environmental Protection Agency
ERL-C	Environmental Research Laboratory at Corvallis, Oregon
FAL	low-range field audit sample
FAO	field audit organic sample triplicate
FAP	field audit sample pair
FD	field duplicate sample
FE_AO	acid oxalate extractable iron
FE_CD	citrate dithionite extractable iron
FE_CL2	iron in 0.002M calcium chloride
FE_PYP	pyrophosphate extractable iron
FIA	flow injection analysis
FP	flame photometry
IC	ion chromatography
ICC	internal consistency checks
ICP	inductively coupled plasma atomic emission spectrometry
IDL	instrument detection limit
IFB	invitation for bid
IQR	interquartile range
IR	infrared detection
K_CL	exchangeable potassium in unbuffered ammonium chloride
K_CL2	potassium in 0.002M calcium chloride
K_OAC	exchangeable potassium in buffered ammonium acetate
LAL	low-range laboratory audit sample
LAO	laboratory audit organic sample triplicate

List of Abbreviations (Continued)

LAP	laboratory audit sample pair
LEVIS	Laboratory Entry and Verification Information System
MASS	Mid-Appalachian Soil Survey
MG_CL	exchangeable magnesium in unbuffered ammonium chloride
MG_CL2	magnesium in 0.002M calcium chloride
MG_OAC	exchangeable magnesium in buffered ammonium acetate
MOIST_A	air-dry soil moisture at the analytical laboratory
MOIST_P	air-dry soil moisture at the preparation laboratory
MQO	measurement quality objective
MS	manager's sample
NA_CL	exchangeable sodium in unbuffered ammonium chloride
NA_CL2	sodium in 0.002M calcium chloride
NA_OAC	exchangeable sodium in buffered ammonium acetate
NCC	National Computer Center
NSS	National Stream Survey
NSWS	National Surface Water Survey
OEPER	Office of Environmental Processes and Effects Research
OM_LOI	organic matter by loss-on-ignition
ORNL	Oak Ridge National Laboratory
PD	preparation duplicate sample
PE	performance evaluation
PH_002M	pH in 0.002M calcium chloride
PH_01M	pH in 0.01M calcium chloride
PH_H2O	pH in deionized water
PH_MP	field-moist pH in deionized water
PLSOP	preparation laboratory standard operating procedures
QA	quality assurance
QART	quality assurance reanalysis template
QC	quality control
QCAS	quality control audit sample
QCCS	quality control check sample
QE	quality evaluation
RF_FG	fine gravel rock fragments
RF_MG	medium gravel rock fragments
RSD	relative standard deviation
SAND	total sand fraction
SAS	Statistical Analysis Systems, Inc.
SBRP	Southern Blue Ridge Province
SCR	soil chemistry relationship
SCS	Soil Conservation Service
SD	standard deviation
SDL	system detection limit
SILT	total silt fraction
SI_AO	acid oxalate extractable silicon
SMO	Sample Management Office
SO4_0	zero mg S/L sulfate isotherm parameter
SO4_2	two mg S/L sulfate isotherm parameter
SO4_4	four mg S/L sulfate isotherm parameter
SO4_8	eight mg S/L sulfate isotherm parameter
SO4_16	sixteen mg S/L sulfate isotherm parameter
SO4_32	thirty-two mg S/L sulfate isotherm parameter
SO4_H2O	water extractable sulfate
SO4_PO4	phosphate extractable sulfate
SOP	standard operating procedures
SOR	SCS state office representative
SOW	statements of work
TC	thermal conductivity
USDA	U.S. Department of Agriculture

Project Summary

The quality assurance (QA) policy of the U.S. Environmental Protection Agency (EPA) requires every monitoring and measurement project to have a written and approved quality assurance project plan. The purpose of this quality assurance plan is to specify the policies, organization, objectives, and the quality evaluation and quality control activities needed to achieve the data quality requirements of the Direct/Delayed Response Project (DDRP), Mid-Appalachian Soil Survey (MASS). These specifications are used to assess and control measurement errors that may enter the system at various phases of the project, e.g., during soil sampling, preparation, and analysis.

Project Description

The DDRP is conducted as part of the interagency, federally mandated National Acid Precipitation Assessment Program which addresses the concern over potential acidification of surface waters by atmospheric deposition within the United States. The overall purpose of the project is to characterize geographic regions of the United States by predicting the long-term response of watersheds and surface waters to acidic deposition.

The EPA is assessing the role that atmospheric deposition of sulfur plays in controlling long-term acidification of surface waters. Recent trend analyses have indicated that the rate of sulfur deposition is either unchanging or slowly declining in the Northeastern United States, but is increasing in the Southeastern United States. If a "direct" response exists between sulfur deposition and surface water alkalinity, then the extent of current effects on surface water probably would not change much at current levels of deposition, and conditions would improve as the levels of deposition decline. If surface water chemistry changes in a "delayed" manner, e.g., due to chemical changes in the watershed, then future changes in water chemistry (even with level or declining rates of deposition) become difficult to predict. This range of potential effects has clear and significant implications to public policy decisions on sulfur emissions control strategies.

The DDRP focuses on regions of the United States that have been identified as potentially sensitive to surface water acidification. The MASS is the third of three DDRP regional surveys and includes portions of Pennsylvania, Virginia, and West Virginia. Surface water acidification in the Mid-Appalachian region was studied during the Eastern Lakes Survey in 1984 and in the National Stream Survey, Phase I, in 1985. Information gained during these and other surveys has been used to optimize the quality assurance program in the MASS.

Field and laboratory data collected in the DDRP are included in the system description modeling. These data are then used to assess the key processes that regulate the dynamics of base cation supply and sulfur retention within watersheds. Integrated watershed data are used to calibrate three dynamic simulation models that predict future regional responses to acidic deposition. Uncertainty and error propagation estimates are an important part of all levels of analysis.

The DDRP staff at the EPA Environmental Research Laboratory in Corvallis, Oregon, is involved in all aspects of the MASS. Responsibilities of this laboratory include the development of an experimental design, QA oversight for soil mapping and sampling, and data analysis and interpretation. The DDRP staff at the EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada, is involved in matters relating to QA implementation, logistics, and analytical services. The responsibilities of this laboratory include the development and implementation of operational procedures and quality evaluation/control criteria for soil sample preparation and analysis, and the development of data verification procedures for field and laboratory data.

The use of interagency agreements by EPA has allowed the DDRP to engage support from several groups that have expertise in areas of importance to the project. The DDRP staff at Oak Ridge National Laboratory is involved in managing, manipulating, and structuring large data bases to satisfy DDRP data analysis requirements. The soil survey staff of the United States Department of Agriculture, Soil Conservation Service is involved in DDRP soil mapping, characterization, and sampling. Laboratory analysis support is solicited through competitive bid on an invitation for bid by independent contract laboratories.

Field and Laboratory Operations

Field mapping and sampling operations in the MASS are conducted by Soil Conservation Service soil scientists under the supervision of EPA representatives. Approximately five sampling crews, each composed of three to four qualified persons, are selected. These crews are responsible for the description of soil and site characteristics, sample collection, and shipment of samples to the preparation laboratory. Members of each crew are soil scientists that are experienced with the universally recognized National Cooperative Soil Survey characterization procedures. The crew leader is responsible for selecting the sampling site and documenting all field data.

The sampling protocols specify the procedures for ensuring the integrity of the samples. Specific instructions on excavating and draining (if necessary) soil pits are given. Crews are provided with standard containers for sample collection. Samples are kept as cool as possible in the field and during transport to the preparation laboratory. In order to maintain their integrity and to reduce the possibility of biological degradation, samples are stored at a temperature of 4°C within 24 hours of sampling. It is anticipated that 150 pedons are to be sampled during the MASS, with each pedon yielding an average of six routine samples from its component horizons.

To allow the determination of bulk density, natural soil clods are collected in triplicate, where possible from each soil horizon. Where clods cannot be collected, known volumes of soil are collected in duplicate. Using a volume replacement method, the volume of soil is estimated by replacing a small excavated soil cavity with a known volume of foam beads. If this method does not yield satisfactory samples, a volume filling method is attempted by filling a container of known volume with soil and attempting to pack it to the same density normally encountered in the horizon being sampled.

The preparation laboratory is the intermediate link between the sampling crews and the analytical laboratories. The laboratory is located at the EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada, although previous DDRP surveys utilized the services of multiple university laboratories for sample preparation. It was thought that consolidating the preparation activities at a single laboratory might result in better sample handling, improved sample integrity, and higher data quality. The laboratory serves as a central location for soil processing and for introducing double-blind measurement quality samples into the sample flow. The soil samples collected by the sampling crews are sent via overnight courier to the preparation laboratory, where the laboratory staff processes the samples and prepares homogeneous, anonymous subsamples that are shipped to the analytical laboratories. To accomplish these tasks successfully, the preparation laboratory must uniformly track, process, and store all samples.

After a bulk soil sample is air dried, the soil is carefully disaggregated and sieved. The less than 2-mm soil is retained in a labeled plastic bottle and placed in cold storage when not undergoing processing. The rock fragments are retained for gravimetric analysis. In order to obtain representative volumes of soil, it is necessary to prepare homogeneous subsamples from the less than 2-mm soil fraction using a riffle splitter. The subsamples are placed in labeled plastic bottles and are organized in batches that are shipped to separate contract analytical laboratories for general and elemental analyses. Each batch normally contains 40 samples but may have as many as 42 samples. With the exception of a quality control audit sample, all samples are randomly placed within a batch and cannot be distinguished by the recipient laboratory. The unused portions of the bulk soil samples are archived in cold storage.

All raw data obtained, are recorded on a series of preparation laboratory raw data forms and are immediately entered into a personal computer to ensure proper tracking, processing, and evaluation of the samples. The computer is directly linked to the QA staff and allows real-time data evaluation and tracking of samples by both parties. The precision and accuracy criteria for measurement quality samples are checked while the samples are being processed, permitting the prompt identification of any discrepancies.

During shipment, the samples received by the analytical laboratories can undergo segregation both by particle size and by density; therefore, each sample must be re-homogenized by thorough mixing prior to the removal of aliquots for analysis. The raw data generated during sample analysis are entered on a personal computer using a specially designed entry and verification system. Data reports are then generated to assist in the evaluation of data quality. Before a batch of analytical data is accepted all completeness and quality control requirements must be met. In addition, the following documents must be updated constantly at the analytical laboratory and must be available, upon request, to the analysts and the supervisor involved in the project: standard operating procedures, laboratory QA plan, list of in-house samples, instrument performance data, control charts for all check samples and detection limit check samples, and quality control data reports.

Frequent communications, i.e., two or three contacts each week, are maintained with each analytical laboratory in order to obtain current sample status and to discuss any problems that may occur during analyses. These discussions are to be recorded in a logbook by the QA staff and the laboratory staff. Preliminary and final data are available for access via electronic transfer. The preliminary data are reviewed for anomalies and if a problem is identified, the laboratory is notified. Corrective action or reanalysis may be suggested.

Legal chain-of-custody procedures are not required for this study; however, sample custody must be documented. The sampling crew leader is responsible for all samples in the field as well as the sample shipments. As soil shipments are received in the preparation laboratory, they are immediately logged in and checked against the packing slip and the pedon description forms for proper labeling and quantity. If any discrepancies are found, the soil sampling task leader and the field crew leader are notified. Following the receipt of samples, the appropriate laboratory managers are responsible for sample integrity until the samples are archived.

Quality Assurance Program

The data collection criteria provide a balance between constraints of time and cost and the quality of data necessary to achieve the DDRP research objectives. The MASS QA Plan is designed to accomplish the following general objectives:

- establish the QA criteria used to control and assess data collected in the survey,
- provide standardized sampling, preparation, and analytical methods and procedures,
- utilize assessment samples and procedures to verify the quality of the data,
- perform field and laboratory on-site audits to ensure that all activities are properly performed and that discrepancies are identified and resolved,
- evaluate the data and document the results in QA reports to EPA management.

The raw soil characterization data for the DDRP surveys are collected during four major operational phases consisting of mapping, sampling, preparation, and analysis. A certain amount of data measurement uncertainty is expected to enter the system at each phase. Grouping of the data, e.g., by sampling class/horizon configurations, also increases uncertainty. The sampling population itself is a source of confounded uncertainty that is extremely difficult to quantify.

Generally, the data quality objectives for the MASS encompass the overall allowable uncertainty from sample measurement and from the sampling population that the data users are willing to accept in the analytical results. Because of the many possible confounded sources of uncertainty and the data collection focus of this QA plan, overall data quality objectives for the survey are not described herein. Rather, the plan focuses on the definition, implementation, and assessment of measurement quality objectives (MQOs) that are specified for the entire sample preparation and analysis phases of data collection and portions of the field sampling phase. The MQOs are more or less specific goals defined by the data users that clearly describe the data quality that is sought for each of the measurement phases. The MQOs are defined according to the following six attributes:

- Detectability -- the lowest concentration of an analyte that a specific analytical procedure can reliably detect,
- Precision -- the level of agreement among multiple measurements of the same characteristic,
- Accuracy -- the difference between an observed value and the true value of the parameter being estimated,
- Representativeness -- the degree to which the data collected accurately represent the population of interest,
- Completeness -- the quantity of data that is successfully collected with respect to the amount intended in the experimental design,
- Comparability -- the similarity of data from different sources included within individual or multiple data sets; the similarity of analytical methods and data from related projects across regions of concern.

An attempt has been made to define each quality attribute individually for each measurement phase of the program (sampling, preparation, analysis) or collectively for overall measurement system uncertainty on a parameter-by-parameter basis. The term "uncertainty" is used as a generic term to describe the sum of all sources of error associated with a given portion of the measurement system. In order to reduce measurement uncertainty in the final data values, error occurring in each phase must be identified and rectified during that phase of the survey. Measurement uncertainty for the MASS is controlled through well-defined protocols, system audits, and the introduction of measurement quality samples at each measurement phase.

Initial MQOs were established on the basis of the requirements of EPA data users and on the selection of appropriate methods to obtain the data. The MQOs were reviewed by persons familiar with analytical methods and soil characterization techniques, including soil chemists and laboratory personnel. Modifications to the MQOs and to the protocols were implemented based on information gained from the DDRP Northeastern region and Southern Blue Ridge Province surveys, from peer review comments, or according to the limitations of a particular analytical procedure or instrument.

Measurement quality samples are placed at a rate of about one sample in four in each batch of analytical samples to determine measurement uncertainty. The measurement quality samples are used during various phases of the survey and allow the QA staff to control and assess the quality of the data collection process. Included in each batch of samples are: audit samples that have known ranges of analyte concentration (detectability, precision, and accuracy), duplicates of routine samples introduced at each measurement phase (precision and representativeness), and an audit sample for use in laboratory quality control (accuracy). There are separate analytical within-batch precision and accuracy MQOs for organic and mineral soils because of differences in methodology and the expected wide variability in analyte concentrations. For this reason, mineral and organic samples are organized and analyzed in separate batches.

Status and Assessment of Measurement Quality Samples

Sample type	# per batch	Status of sample[a]				Assessment purpose[b]			
		QA staff	Sampling crew	Preparation laboratory	Analytical laboratory	System	Sampling	Preparation	Analysis
Low-range field audit*	1	K	B	B	DB	D,A	D,A	D,A	A
Field audit pair**	2	K	B	B	DB	P,A	P,A	P,A	P,A
Field duplicate	1	–	B	B	DB	P	P,R	P	P
Low-range lab audit*	1	K	–	–	DB	–	–	–	D
Lab audit pair**	2	K	–	–	DB	–	–	–	P,A
Preparation duplicate	2	–	–	B	DB	–	–	P,R	P
Quality control audit	1	K	–	–	B	–	–	–	A
Manager's sample	–	K	–	B	–	–	–	A	–

[a] K = known concentration, B = blind, DB = double blind.
[b] D = detectability/contamination, P = precision, A = accuracy, R = representativeness.
* Not placed in organic soil batches.
** Triplicate in organic soil batches.

The quality evaluation samples are those samples which are known to the QA staff but are either blind or double blind to the sampling crews, preparation laboratory, or analytical laboratory. A blind sample has a concentration range that is unknown to the analysts, whereas a double blind sample cannot be distinguished from a routine sample and has a concentration range that is unknown to the analyst. These samples provide an independent check on the analytical process and can be used to evaluate whether the MQOs have been met for any given run or batch, or for all batches, i.e., overall measurement uncertainty. Important characteristics of the audit samples include their similarity to routine samples in matrix type and concentration level, their homogeneity and stability, and their defined accuracy windows. Every quality evaluation sample has a specific purpose in the data assessment scheme.

In order to produce data of consistently high quality, the contract laboratories are required to analyze certain types of quality control samples that are known to the laboratory staff and that can be used by the analysts to identify and control analytical measurement uncertainty. Each of these samples has certain specifications that must be met before data for the parameter or batch are accepted. The control samples are non-blind samples procured under contract to assist the laboratories in meeting laboratory MQOs and include soil samples, e.g., analytical duplicates, and non-soil samples, e.g., reagent blanks. The samples allow the laboratory manager and the QA staff to assess whether the physical and chemical analysis is under control.

Quality Assurance Implementation

The quality assurance program is implemented through training, on-site systems audits, independent assessments, and other procedures used to control and assure the quality of the data being collected. Verification of these data is accomplished through a series of computer and manual checks of data quality.

Corrective action for errors made at the preparation and analytical laboratories is accomplished primarily through the application of a QA reanalysis template for each analysis of interest. The templates provide a precision and accuracy checklist of the measurement quality samples for each batch and are useful in deciding whether to reanalyze a particular parameter.

The analytical data verification is a multi-faceted, computerized approach to provide a concise and consistent assessment of the data. The overall process is highlighted by the Laboratory Entry and Verification Information System (LEVIS). The LEVIS programs are implemented on personal computers and facilitate the data entry and quality control sample evaluation at the analytical laboratories as well as the evaluation of laboratory performance by the QA staff. The system is a menu-driven product that is designed as a two-phase operation, where phase one is an analytical laboratory system and phase two is a quality assessment system. The LEVIS initiative was pursued because previous surveys had shown that manual verification of the data was both labor- and time-intensive, and allowed only a limited amount of real-time corrective action on the part of the laboratories.

An internal consistency program is used to generate routine data outliers in each sample batch. Analytical data from each parameter are correlated against corresponding data from all other analytical parameters measured in the MASS. For each parameter, the parameter pair with the strongest linear relationship is identified and evaluated. Soil chemistry relationships are another tool used to examine the internal consistency of the routine sample data. It is expected that approximately 10 percent of the data will not comply with the relationships; these anomalous data are examined by a staff soil chemist who either qualifies them or assigns appropriate flags signifying the discrepancy.

Data Quality Assessment and Reporting

The assessment of detectability is accomplished on a parameter basis at four levels: 1) compliance with contract-required detection limits; 2) calculation of actual instrument detection limits; 3) calculation of estimated system detection limits; and 4) identification of routine samples having concentrations below the system detection limits. The results can be grouped in tabular form to allow comparisons among the values for any parameter of interest.

A statistical evaluation procedure that has been developed by the QA staff and data users is applied to the data in order to assess precision as a function of confounded data collection uncertainty. An additive step-function model is used, where an observed value of any soil characteristic is considered as the sum of the "true" or accepted value and an error term. Precision is evaluated for each variance segment of the range of concentration for a given analyte.

The accuracy windows for the laboratory audit samples are based on previous interlaboratory analyses of the same sample material by the same protocols. The objective of setting windows is to specify a range of acceptable single values based on a mean and standard deviation computed from a number of previously observed values. The prediction intervals used for the accuracy windows are generally determined with confidence intervals constructed around the mean of these values, using appropriate weighting factors.

The sampling aspect of representativeness is assessed by comparing the individual site and pedon classifications with the component sampling classes to which the soils are assigned. Representativeness of the measurement quality samples is assessed by comparing the concentration ranges of data from the duplicate samples to the overall concentration range of the routine sample data. Representativeness of the analytical samples is identified by assessing the homogenization and subsampling procedures at the preparation and analytical laboratories using precision estimates from the duplicate samples.

Sampling completeness is assessed by comparing the actual number of soil pedons and associated horizons sampled to that number specified in the MASS design. Completeness of the sample collection, preparation, and analysis is calculated using data from the verified data base, while completeness of the data from a data user's perspective, i.e., amount of usable data, is determined using the validated data base.

Following completion of the MASS, a comparison is made across the Northeastern, Southern Blue Ridge, and Mid-Appalachian regions that focuses on method differences, audit sample results, laboratory effects, and other QA features of the surveys. Comparison of the DDRP data bases to other similar data bases may also be undertaken. Summary statistics are used to collate individual values into groups that enable the data users to discern trends of interest among the surveys.

Task leaders for the various stages of the MASS provide a written summary of operations to the project managers on a quarterly basis. These reports describe the kinds of data collected as well as summarize the QA activities associated with the data. The summary of QA activities includes the following:

- Overview of QA activities,
- List of changes to the QA program,
- Results of system and performance audits,
- Assessment of data quality based on the verified data bases,
- Documentation of unfavorable incidents and corrective actions,
- Distribution of updated control charts,
- Results of special studies.

Reports relating to data quality assessment are also prepared by QA staff. These reports include interpretation of performance audits and replicate sample data, estimates of measurement error, and identification of any major discrepancies found during the assessment. In addition to this QA Plan, the QA staff produces laboratory operations manuals for use in the preparation and analysis of soil samples. Upon completion of the data verification activities, summary QA reports of the sample preparation and sample analysis data are produced and distributed to all cooperating DDRP staff and data users.

Data Management System

The purpose of data base management for the MASS is to facilitate the collection, entry, review, modification, and distribution of all data associated with the survey. Additional tasks include the data analysis for report generation, statistical analysis, verification, and data file security. The MASS final data base contains three progressive versions of the data gathered: (1) raw data base, (2) verified data base, and (3) validated data base.

Section 1

Introduction

1.1 Directives

The quality assurance policy of the U.S. Environmental Protection Agency (EPA) requires every monitoring and measurement project to have a written and approved quality assurance (QA) project plan (Costle, 1979a and 1979b). This requirement applies to all environmental monitoring and measurement efforts authorized or supported by EPA through regulations, grants, contracts, or other formal means. The purpose of this QA plan is to specify the policies, organization, objectives, and the quality evaluation (QE) and quality control (QC) activities needed to achieve the data quality requirements of the Direct/Delayed Response Project (DDRP), Mid-Appalachian Soil Survey (MASS). These specifications are used to assess and control measurement errors that may enter the system at various phases of the project, e.g., during soil sampling, preparation, and analysis.

All project personnel are expected to be familiar with the policies and objectives outlined in this QA plan to ensure proper interactions between field and laboratory operations and data management.

1.2 Sources of Information

The EPA Quality Assurance Management Staff guidelines (Stanley and Verner, 1985) state that the QA project plan should address, in detail or by reference, each of the 14 items listed in Table 1-1. Method-specific discussions presented in the DDRP-MASS Soil Sampling Manual (Kern et al., 1988), the DDRP-MASS Preparation Laboratory Standard Operating Procedures (Bartling et al., 1988), or the DDRP-MASS Analytical Laboratory Statements of Work (USEPA, 1988) might not be repeated in this project plan. In these cases, Table 1-1 serves as an index to the appropriate references.

Table 1-1. Sections in This Quality Assurance Project Plan and in Other DDRP Documents Where Quality Assurance Subjects are Addressed

	Section Number			
Subject	QA Project Plan	Soil Sampling Manual^a	Preparation Laboratory SOP^b	Analytical Laboratory SOW^c
Project Description	2	1,2	1	1
Project Organization	2	1,2	1	1
QA Objectives for Measurement Data	5	—	2	3
Sampling Procedures	3,4	7	—	—
Sample Custody and Storage	4	7,8	2	2
Calibration Procedures	—	—	2,3	3
Analytical Procedures	4	—	3	4

(continued)

Table 1-1. Continued

Subject	QA Project Plan	Soil Sampling Manual[a]	Preparation Laboratory SOP[b]	Analytical Laboratory SOW[c]
	Section Number			
Data Reduction, Validation, and Reporting	7,8	6,7	2,3	4,5
QC Standards and Checks	5,6	—	2,3	3,4
Performance and System Audits	7	2,6	1	6
Preventive Maintenance	6	—	3	3,4
Data Quality Assessment	6,7	—	2,3	3,4
Corrective Actions	6,7	2,6	2,3	3,4
QA Reports	7	2	2	3

[a] Kern et al., 1988
[b] Bartling et al., 1988
[c] USEPA, 1988

Section 2

Project Description

2.1 Project Overview

The DDRP is an integral part of the Aquatic Effects Research Program (AERP) of the EPA and is conducted as part of the interagency, federally mandated National Acid Precipitation Assessment Program (NAPAP) which addresses the concern over potential acidification of surface waters by atmospheric deposition within the United States. The overall purpose of DDRP is to characterize geographic regions of the United States by predicting the long-term response of watersheds and surface waters to acidic deposition.

The DDRP has been designed under the concept of regionalized integrative surveys which initially are approached from a large region of study and lead to the selection and study of regionally characteristic systems. These systems can be assessed through detailed, process-oriented research which aid in the understanding of the underlying mechanisms responsible for observed effects. The projected responses of watershed systems typical of the regional population can then be extrapolated to a regional or national scale.

The EPA is assessing the role that atmospheric deposition of sulfur plays in controlling long-term acidification of surface waters (USEPA, 1985). Recent trend analyses have indicated that the rate of sulfur deposition is either unchanging or slowly declining in the Northeastern United States, but is increasing in the Southeastern United States. If a "direct" response exists between sulfur deposition and surface water alkalinity, then the extent of current effects on surface water probably would not change much at current levels of deposition, and conditions would improve as the levels of deposition decline. If surface water chemistry changes in a "delayed" manner, e.g., due to chemical changes in the watershed, then future changes in water chemistry (even with level or declining rates of deposition) become difficult to predict. This range of potential effects has clear and significant implications to public policy decisions on sulfur emissions control strategies.

The DDRP focuses on regions of the United States that have been identified as potentially sensitive to surface water acidification. The Northeastern Soil Survey was conducted in 1985 in the New England states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, and portions of New York and Pennsylvania. The Southern Blue Ridge Province Soil Survey was conducted in 1986 in portions of Virginia, Tennessee, North Carolina, South Carolina, and Georgia. The Mid-Appalachian Soil Survey (MASS) includes portions of Pennsylvania, Virginia, and West Virginia (see Figure 2-1). Surface water acidification in these regions was studied during the Eastern Lakes Survey in 1984 and in the National Stream Survey, Phase I, in 1985.

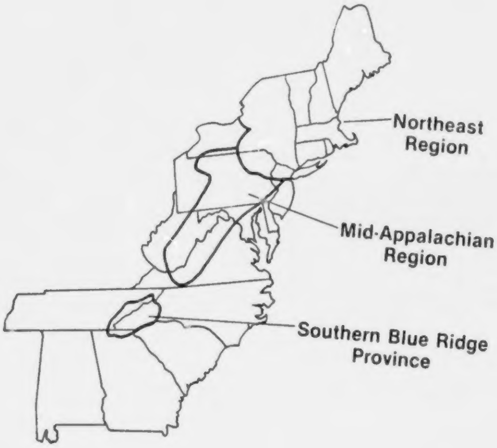


Figure 2-1. Regional Surveys of the Direct/Delayed Response Project (from Lee et al., 1989)

Specific goals of the DDRP are to (1) characterize the variability of soil and watershed attributes across these regions, (2) determine which of the soil and watershed characteristics are most strongly related to surface-water chemistry, (3) estimate the relative importance of key watershed processes in controlling surface water chemistry across the regions of concern, and (4) classify the sample of watersheds with regard to their response characteristics and extrapolate the results from the sample of watersheds to the regions of concern (USEPA, 1989). Figure 2-2 displays a general outline of the DDRP activities in support of these goals.

A variety of data sources and methods of analysis are used to address the objectives of DDRP. In addition to the data collected during DDRP, other data sources include the following data bases:

- National Surface Water Survey (NSWS) [water chemistry data],
- Acid Deposition Data Network (ADDNET), including GEOECOLOGY [atmospheric precipitation chemistry data],
- Soil Conservation Service (SCS) Soils-5 [soil physical and chemical data],
- Topographic and Acid Deposition System (ADS) [total sulfur deposition data],
- U.S. Geological Survey [runoff data].

Also, data from EPA long-term monitoring sites, episodic event monitoring sites, and intensively studied watersheds are used in the data analysis. The data that are collected are analyzed at three levels. Level I involves the system description and statistical analysis, Level II provides single factor response-time estimates, and Level III involves dynamic systems modeling.

Field and laboratory data collected in the DDRP and NSWS are included in the Level I system description. These data are used in Level II models to assess the key processes that regulate the dynamics of base cation supply and sulfur retention within watersheds. Integrated watershed data are used in Level III to calibrate three dynamic simulation models, MAGIC (Cosby et al., 1984), ILWAS (Chen et al., 1984), and Trickle-Down (Schnoor et al., 1984), that predict future regional responses to acidic deposition. Uncertainty and error propagation estimates are an important part of all three levels of analysis (USEPA, 1989).

2.2 Project Organization

Figure 2-3 illustrates the operational management structure of the MASS and Figure 2-4 illustrates the local organizational management of the QA staff. The director of the Office of Environmental Processes and Effects Research (OEPER) is the EPA official who has overall responsibility for programs within EPA that address the effects of acidic deposition.

2.2.1 Project Management

The EPA management structure for the DDRP surveys is described in the following subsections.

2.2.1.1 Program Director

The program director of the Aquatic Effects Research Program is the EPA Headquarters representative for DDRP and is the liaison between the headquarters staff, the laboratory directors, and NAPAP. Questions regarding general management and resources should be forwarded to the program director through the technical director.

2.2.1.2 Technical Director

The DDRP technical director is assigned tasks at the discretion of the AERP director. The primary role of the technical director is to maintain the integrity of program objectives, to integrate components of the program, and to ensure that deadlines are met. The technical director coordinates and integrates the DDRP activities of the EPA Environmental Research Laboratory at Corvallis, Oregon (ERL-C) and the Environmental Monitoring Systems Laboratory at Las Vegas, Nevada (EMSL-LV). The technical director coordinates peer reviews, resolves issues of responsibility, and disseminates information to the public. The technical director represents the program director as necessary and informs the program director

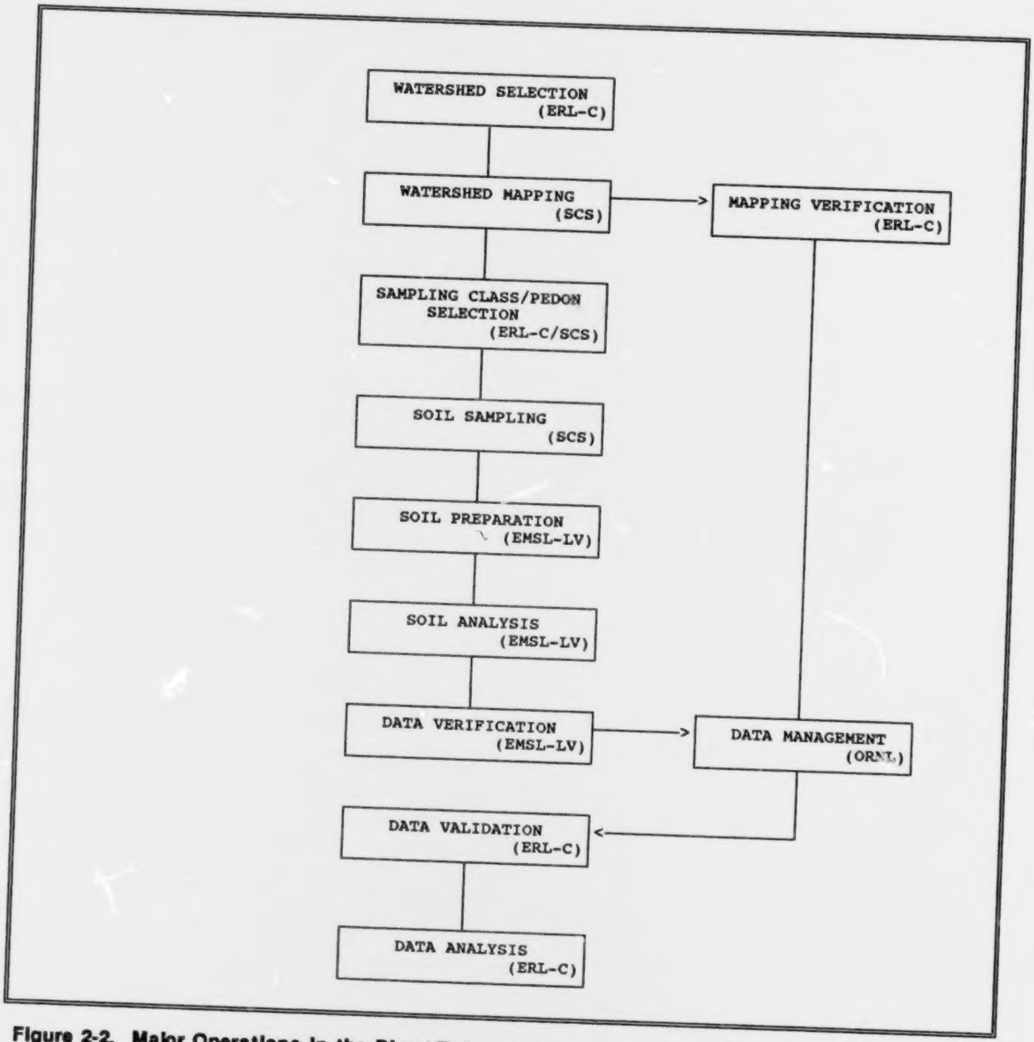

WATERSHED SELECTION (ERL-C)
WATERSHED MAPPING (SCS)
MAPPING VERIFICATION (ERL-C)
SAMPLING CLASS/PEDON SELECTION (ERL-C/SCS)
SOIL SAMPLING (SCS)
SOIL PREPARATION (EMSL-LV)
SOIL ANALYSIS (EMSL-LV)
DATA VERIFICATION (EMSL-LV)
DATA MANAGEMENT (ORNL)
DATA VALIDATION (ERL-C)
DATA ANALYSIS (ERL-C)

Figure 2-2. Major Operations in the Direct/Delayed Response Project Mid-Appalachian Soil Survey

of EPA laboratory activities, progress, and performance.

2.2.1.3 Technical Monitor

A technical monitor at each EPA laboratory is responsible for specific DDRP tasks assigned by the technical director. Responsibilities include the employment and coordination of groups of individuals to accomplish the assigned tasks. The technical monitor performs reviews and audits, resolves issues of responsibility, and informs EPA management of progress and performance. The ERL-C technical monitor has the primary responsibility for soil mapping and sampling activities. The EMSL-LV technical monitor has the primary responsibility for soil preparation and physical /chemical analysis activities.

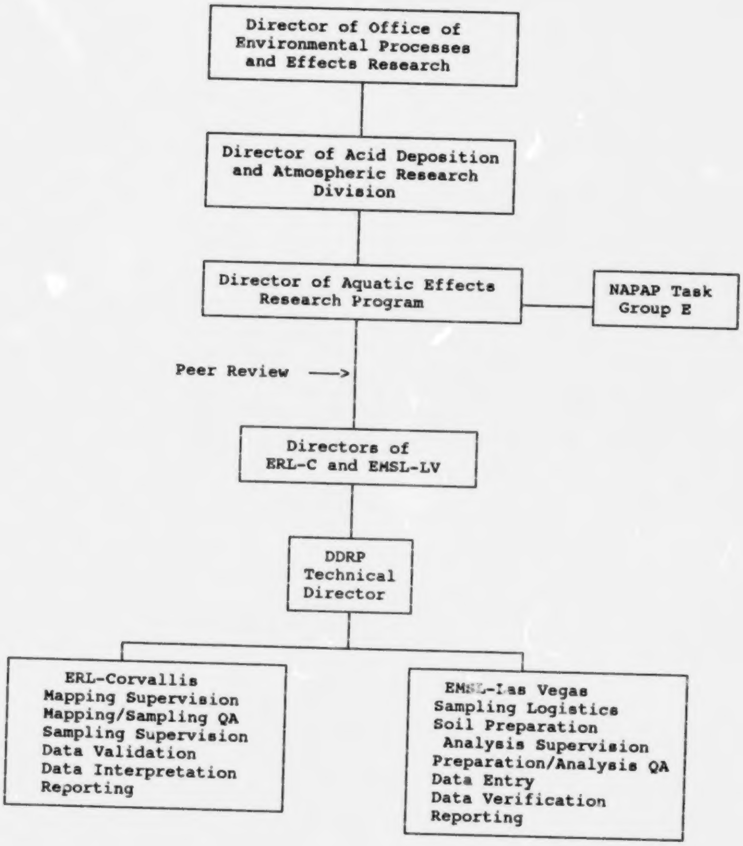

Director of Office of Environmental Processes and Effects Research
Director of Acid Deposition and Atmospheric Research Division
Director of Aquatic Effects Research Program
NAPAP Task Group E
Peer Review ——>
Directors of ERL-C and EMSL-LV
DDRP Technical Director
ERL-Corvallis
Mapping Supervision
Mapping/Sampling QA
Sampling Supervision
Data Validation
Data Interpretation
Reporting
EMSL-Las Vegas
Sampling Logistics
Soil Preparation
Analysis Supervision
Preparation/Analysis QA
Data Entry
Data Verification
Reporting

Figure 2-3. Operational management structure for the Mid-Appalachian Soil Survey of the Direct/Delayed Response Project.

2.2.1.4 Quality Assurance Officer

The QA officer is responsible for ensuring that each project within an EPA laboratory satisfies the agency's requirements for QA programs. The QA officer evaluates QA plans, coordinates and supervises system audits, disseminates information, and is responsible for the coordination and oversight of the division QA officers.

2.2.1.5 Division Quality Assurance Officer

The division QA officer is tasked with overseeing the QA operations of specific tasks or projects. Responsibilities include facilitating the attainment of quality objectives, coordinating system audits, and resolving QA issues relating to a specific project. The division QA officer acts as a liaison with the QA staff and technical monitor in addressing QA issues.

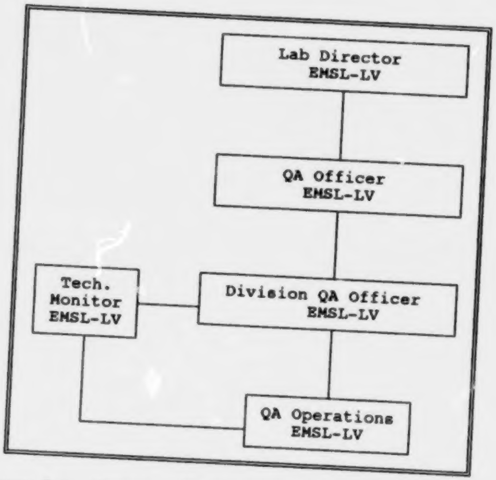


Figure 2-4. Organizational management structure of the Quality Assurance Staff at the Environmental Monitoring Systems Laboratory, Las Vegas, Nevada

2.2.2 Laboratory Responsibilities

A summary of the different DDRP staff responsibilities at each cooperating laboratory is provided below.

2.2.2.1 Environmental Research Laboratory, Corvallis, Oregon

The DDRP staff at ERL-C is involved in all aspects of the DDRP soil surveys. Responsibilities of ERL-C personnel for the overall program include:

- developing the experimental design and QA oversight for soil mapping and sampling,
- collecting supplemental historical and other available data on each sampling site,
- coordinating the temporary storage of samples in the field and their transfer to the preparation laboratory,
- analyzing and validating data (jointly with EMSL-LV),
- interpreting data,
- preparing reports (final and progress reports with contributions from the other laboratories relative to their responsibilities),
- assessing and resolving all science-related issues other than QA or data management (jointly with other laboratories as necessary),
- coordinating survey activities with NAPAP management staff.

2.2.2.2 Environmental Monitoring Systems Laboratory, Las Vegas, Nevada

The DDRP staff at EMSL-LV has expertise in matters relating to QA implementation, logistics, and analytical services. The responsibilities of personnel at EMSL-LV include:

- developing QE/QC procedures for all sample preparation and analysis components,
- developing and implementing preparation laboratory and analytical laboratory operating procedures,
- developing and implementing analytical methods,
- coordinating logistical support and equipment needs for all field and preparation laboratory operations,
- distributing processed samples to analytical laboratories,
- developing and implementing the verification and management procedures for sampling, preparation, and analytical data,
- developing and implementing the QA project plan and corresponding laboratory manuals,
- analyzing data (jointly with ERL-C),
- preparing QA data reports for preparation laboratory and analytical laboratory operations,
- resolving issues pertaining to QE/QC, logistics, and analytical services.

2.2.3 Primary Cooperators

The use of interagency agreements by EPA has allowed the DDRP to tap support from several groups that have expertise in areas of importance to the project, as outlined below.

2.2.3.1 Oak Ridge National Laboratory, Oak Ridge, Tennessee

The DDRP staff at ORNL has expertise in managing, manipulating, and restructuring large data bases to satisfy data analysis needs. ERL-C oversees the activities of ORNL, which has responsibilities for:

- developing and maintaining a data base management system,
- preparing computer-generated summary tables, statistics, and graphics for reports,
- assisting with data validation and interpretation activities.

2.2.3.2 Soil Conservation Service

The United States Department of Agriculture (USDA) Soil Conservation Service (SCS) has expertise in soil mapping and characterization on a national scale. Under the supervision of ERL-C, the SCS has responsibilities for:

- soil mapping of the MASS watersheds,
- site selection and characterization,
- soil sampling of selected pedons.

Section 3

Sampling Strategy

Following is a brief summary of the considerations involved in designing the MASS sampling strategy. Additional details are provided in documents prepared by the DDRP staff at ERL-C, who had the primary responsibility for sampling in the MASS.

3.1 Watershed Selection and Mapping

Since the objectives of the DDRP are focused on making regional inferences, the watersheds selected for mapping of soils and watershed characteristics must constitute a representative sample of a region. After eliminating watersheds having known acid mine drainage and prohibitively large watersheds exceeding 3,000 hectares in area, 79 watersheds included in the Pilot Survey of the National Stream Survey - Phase I (NSS-I) provided an excellent starting point from which to draw the subsample for MASS. These watersheds satisfied the requirements because: (1) the NSS-I pilot survey stream reaches were selected according to a rigorous probability sampling method, i.e., the reaches were stratified by three subregions and three alkalinity classes within each subregion, and (2) water chemistry information was available from NSS-I for the reaches (Messer et al., 1986).

The preliminary procedure for selecting the MASS watersheds consisted of eliminating certain watersheds according to strictly defined criteria, as follows:

- acid-neutralizing capacity (ANC) of greater than 200 microequivalents per liter,
- suspected residual effects of acid mine drainage,
- a geomorphic history of Pleistocene glaciation within the northern portion of the Mid-Appalachian region.

Twenty-three watersheds having high ANC were deleted because they were considered to be at low risk for future acidification. Twelve watersheds identified as harboring mine spoils or other disturbances were deleted because of their anticipated inordinate effect on chemical characteristics of the soils. Seven watersheds with a history of glaciation were deleted because it was decided that soils in these areas would exhibit characteristics similar to those soils previously sampled in the DDRP Northeastern Soil Survey. Hence, 37 watersheds from NSS-I remained for potential sampling in the MASS.

The 37 watersheds were mapped during the Autumn of 1987 and the Spring of 1988 according to the mapping protocols (Lammers et al., 1988). With the exception of certain highlighted modifications, the protocols are based on standard procedures developed for the National Cooperative Soil Survey (NCSS) and also describe the preparation of uniform soil profile descriptions, mapping legends, and the QA program for mapping. A second order soils map at a 1:24,000 scale is specified. Mapping units are mostly consociations and complexes, and the components of the mapping units are phases of soil series, higher categories, or miscellaneous areas. Contrasting inclusions are limited to a maximum of 20 percent for soil components and 15 percent for miscellaneous areas.

Field review and evaluation of the mapping by the soil mapping task leader, a Soil Conservation Service (SCS) state office representative (SOR), and an independent regional correlator/coordinator (RCC) ensures the consistent application of the mapping protocols and the correlation of mapping units among the mapping parties. Soil map adequacy is qualitatively evaluated for soil features relevant to the DDRP, such as permeability or slope class. Correctness of the mapping is determined by point observations along selected transects using an approach similar to that outlined in Steers and Hajek (1979). Both the degree of error and the number of errors are considered for a designated size area. Key mapping and supervisory personnel attend a final correlation workshop to review and correlate the mapping units and delineations across the region.

3.2 Selection of Sampling Classes

Sampling each of the soil mapping units is not necessarily the best way to describe the chemistry of the soils in a region. A more straightforward procedure is to combine the mapping units into groups, or sampling classes, which are either known to have or are expected to have similar characteristics. Each of these sampling classes can be sampled from a number of watersheds, and the mean characteristics of each sampling class can be computed. The mean and variance values can be used to construct area-weighted or volume-weighted estimates of the characteristics for each watershed. For this procedure to work, at least five samples must be taken to characterize the variability of each sampling class. The objective is to develop a method of grouping the large number of soils into a reasonable number of sampling classes. The spatial distribution of mapping units and the relative proportion of the components of the mapping units are used to aggregate the watershed attributes.

Specific information relating to sampling classes can be found in the sampling protocols (Kern et al., 1988).

Section 4

Field and Laboratory Operations

This section outlines the operational and logistical activities required for the sampling, preparation, and analysis of soils for the MASS. Specific information on the individual phases can be found in the soil sampling manual (Kern et al., 1988), the preparation laboratory standard operating procedures (Bartling et al., 1988), and the analytical laboratory statements of work (USEPA, 1988), respectively.

4.1 Field Operations

Field operations are conducted under the supervision of ERL-C staff. The primary participants are SCS soil scientists tasked through an interagency agreement. Complete details of the MASS field operations can be found in the mapping protocols (Lammers et al., 1988) and the sampling manual (Kern et al., 1988).

4.1.1 Personnel

Approximately five sampling crews, each composed of three to four qualified persons, perform the field sampling operations for the MASS. These crews are responsible for the description of soil and site characteristics, sample collection, and shipment of samples to the preparation laboratory. Members of each crew are soil scientists experienced in the National Cooperative Soil Survey characterization procedures. The crew leader is responsible for selecting the sampling site and documenting all field data.

4.1.2 Sampling Activities

Several steps are necessary to complete soil sampling activities at a particular site; descriptions of these activities follow.

4.1.2.1 Description of Sampling Site and Soil Profile

After the sampling site is located a pit large enough for sampling all major horizons is excavated to a depth of 2.0 meters or to bedrock. The soil profile is described according to the sampling protocols and the data are recorded on an SCS-SOI-232 field data form (see Appendix A). Other descriptive information, e.g., site characteristics or herbicide contamination, also is recorded on the field data form.

4.1.2.2 Sampling Procedure

For each soil horizon greater than 3 centimeters thick identified on the field data form, the sampling crew collects a soil sample weighing approximately 5.5 kilograms after sieving to exclude rock fragments exceeding 20 millimeters in diameter. A sufficient quantity of sample should be collected to ensure that a minimum of 2 kg of less than 2-mm material is available after sample preparation. Sample bags are labeled with DDRP Label A (see Appendix A) which identifies the date the sample was taken, the crew that collected the sample, and the appropriate site, sample, and set ID codes. The thirteen-character sample code is an alpha-numeric coding of the sample type, e.g., routine, audit, or field duplicate; the number of bags per sample; the SCS state and county code; and the pedon/horizon code. The identification and sample numbering scheme yields unique alpha-numeric labels for each pedon and for each sample collected from the pedon.

The sampling protocols specify the procedures for ensuring the integrity of the samples. Specific instructions on excavating and draining (if necessary) soil pits are given. Crews are provided with standard containers for sample collection. Samples are kept as cool as possible in the field and during transport to the preparation laboratory. To maintain their integrity, samples are to be stored at an ambient air temperature of 4 °C within 24 hours of sampling. This can be accomplished by temporarily storing the samples in rented cold lockers or in styrofoam coolers with frozen gel packs.

It is anticipated that 150 pedons are to be sampled during the MASS, with each pedon yielding an average of six routine samples from the component horizons.

4.1.2.3 Collection of the Field Duplicate Sample

Each sampling crew samples one horizon in duplicate from every third pedon. The type of horizon chosen for this field duplicate (FD) sample is based on random selection, although the crew is instructed to avoid continuous sampling of the same type of horizon to ensure that FDs for each crew are sampled across the complete range of possible horizons.

The sampling procedure specifies that the FD and its corresponding routine sample are collected simultaneously. Alternate trowels-full of soil are removed from the horizon and are placed into separate sample bags until two samples of fine earth material equal to approximately 5.5 kg each are collected. The FDs are processed and analyzed in the same manner as the routine soil samples. The analytical results are used in the assessment of measurement variability attributed to sampling, preparation, and analysis that contribute to the overall measurement uncertainty.

4.1.2.4 Handling of the Field Audit Samples

Field audit samples are supplied to the crews by the QA staff. On each day that crews sample the FD, they are required to sieve, rebag, and label three audit samples while at the sampling site. The samples are sent with the routine samples to the preparation laboratory for processing and subsequently to the analytical laboratories for analysis. The results are used to assess the overall measurement uncertainty and system-wide detectability.

4.1.2.5 Collection of the Bulk Density Samples

To allow the determination of bulk density, natural soil clods are collected in triplicate, where possible from each soil horizon. The clods are placed in hairnets and dipped in a saran solution to preserve their structural integrity during transport to the preparation laboratory. The clods are carefully packed in clod boxes with cushioned packing material to absorb excess shock and vibration during transport.

Where clods cannot be collected, known volumes of soil are collected in duplicate. The volume of soil is estimated by replacing a small excavated cavity with a known volume of foam beads. If the clod method or volume replacement method do not yield satisfactory samples, a volume filling method is initiated by filling a container of known volume with soil and attempting to pack it to the same density normally encountered in the horizon being sampled.

4.1.2.6 Sample Shipments

Sampling crews are responsible for the shipment of soil samples and pedon descriptions to the preparation laboratory. Shipments must include a packing slip detailing the number of boxes sent and the contents of the shipment, i.e., number of samples and forms. An overnight courier service is used for shipment of all bulk samples. Clods are shipped in clod boxes packed inside of styrofoam coolers.

4.2 Preparation Laboratory Operations

The preparation laboratory is located at EMSL-LV and is the intermediate link between the sampling crews and the analytical laboratories. The bulk soil samples collected by the sampling crews are sent via overnight courier to the preparation laboratory, where the laboratory staff processes the samples and prepares homogeneous, anonymous subsamples that are shipped to the analytical laboratories. To accomplish these tasks successfully, the preparation laboratory must uniformly track, process, and store all samples. Complete details of the preparation laboratory activities are prescribed in the PLSOP (Bartling et al., 1988).

4.2.1 Personnel

Preparation laboratory operations are performed by approximately six laboratory analysts under the supervision of the preparation laboratory manager. The manager must be an experienced soil scientist and has the responsibility of training and supervising the analysts. Each analyst is responsible for certain processing activities and is required to uniformly enter raw data on specified data forms.

4.2.2 Preparation Activities

Sample preparation involves a number of activities in order to produce homogeneous and representative subsamples of soil for analysis, as described below.

4.2.2.1 Sample Receipt

The sampling crew member responsible for shipping samples notifies the laboratory manager when samples are shipped from the sampling sites to the preparation laboratory. Bulk samples and completed packing lists are shipped via overnight courier directly to the EMSL-LV cold storage facility. All incoming soil samples are received by preparation laboratory personnel, who record information for the samples on the Sample Receipt Raw Data Form (see Appendix B). Additional notes must be kept in a logbook that is submitted to the QA manager at the end of the survey.

Each shipment is checked upon arrival to ensure that all samples sent have been received. The condition of the samples is noted on the receipt form and any samples that are damaged or missing are reported to the QA manager. Samples are grouped in sets that are maintained throughout storage, processing, and shipping.

The original field data forms and photocopies of the appropriate sampling forms are included in the sample shipment. Information on these forms is used to check sample labeling and to document the receipt of samples. The forms are then forwarded to the QA manager.

4.2.2.2 Sample Storage

All soil samples are placed in cold storage immediately upon receipt and remain there until they undergo further processing. After air drying, the samples are returned to cold storage and remain there when not undergoing processing. Cold storage is required to maintain sample integrity and to minimize microbial degradation. The laboratory analyst responsible for sample storage organizes the samples for easy and efficient access. The cold storage area is maintained at a temperature of 4 °C and is monitored regularly.

4.2.2.3 Sample Processing and Analysis

Sample integrity is protected during all steps of sample handling. The unique identity of each sample is maintained by labeling with the sample code, by documenting the status of each sample through all processing and analyses, and by avoiding physical and chemical contamination during each processing step. The analyses specified in Table 4-1 and in Appendix C are accomplished at the preparation laboratory. These include field-moist pH, air-dry moisture, organic matter by loss on ignition, rock fragments, and bulk density.

Bulk samples are allowed to air dry in a contamination-protected room until they achieve a prescribed moisture content. Any observations of microbial growth or other unusual characteristics are noted in a logbook. If the calculated moisture content of a composite subsample is below 2.5 percent for mineral soils or below 6.0 percent for organic soils, the sample is considered air dry.

Table 4-1. Preparation Laboratory Parameters and Corresponding Analytical Techniques

Parameter	Technique
PH_MP	Combination electrode/millivoltmeter
MOIST_P	Gravimetric
OM_LOI	Loss on ignition
RF_FG, RF_MG	Sieve/gravimetric
BD_CLD	Displacement/gravimetric
BD_KV	Replacement/gravimetric

If samples labeled as organic soil have less than 20 percent organic matter or samples labeled as mineral soil have greater than 20 percent, the QA manager and the soil sampling task leader are notified immediately for further instructions concerning the affected samples.

After a bulk sample is air dry, the soil is carefully disaggregated and passed through nested 4.75-mm and 2-mm sieves. After sieving, the less than 2-mm soil is retained in a labeled plastic bottle and placed in cold storage when not undergoing processing. The rock fragments are retained for gravimetric analysis (note: fragments exceeding 20 mm in diameter are removed in the field). The fragments are then placed in a pre-labeled plastic bag and are archived by set.

In order to obtain representative volumes of soil, it is necessary to prepare homogeneous subsamples from the less than 2-mm fraction of the bulk samples. Two subsamples of each bulk sample are obtained through use of a Jones-type riffle splitter. The subsamples are placed in plastic bottles labeled with DDRP Label B (see Appendix B) and are organized by batch in cold storage to await shipment to separate contract analytical laboratories for general and elemental analyses. The unused portions of the bulk soil samples are stored in labeled plastic bottles and are archived by set in cold storage.

Bulk density is defined as weight per unit volume expressed in grams per cubic centimeter (g/cm^3). Generally, three clod samples or two known volume samples are extracted from each horizon. The mean of the replicate bulk density values is accepted as the bulk density of a particular horizon.

All raw data obtained, are recorded on a series of preparation laboratory raw data forms (see Appendix B). All data obtained are immediately entered into the computer to ensure proper tracking, processing, and evaluation of the samples. Calculated data from all of the preparation laboratory analyses are recorded on the summary data form, Form 101, which is compiled during the batching of samples. The raw data recorded in logbooks or on data forms must be submitted to the QA manager upon completion of the MASS preparation activities.

4.2.2.4 Data Entry

Preparation laboratory personnel have access to a personal computer directly linked to the QA staff that allows real-time data evaluation and tracking of samples by both parties. Data entry screens are developed for entering information from the raw data forms used by the analysts. All raw data obtained during sample receipt and sample analysis are entered into a temporary file in the computer by laboratory personnel. The verification programs are run and printouts of the calculated data and suspect values are generated (see Section 6.2 and Appendix D). The precision and accuracy criteria for QE/QC samples are checked while the samples are being processed, permitting the prompt identification of any discrepancies.

The laboratory manager ensures that computer entry is current at all times and checks the calculated data for outliers and other possible discrepancies. A computer-generated spreadsheet shows the status of all samples received, samples being processed, and samples shipped. The computer program produces summary data forms that contain the final data values.

4.2.2.5 Batch Formation and Sample Shipment

Batches of processed soil samples are assembled as specified in the PLSOP and shipped to the designated analytical laboratories. Each batch normally contains 40 samples but may have as many as 42 samples. With the exception of the QC audit sample (QCAS), all samples are randomly placed within a batch and cannot be distinguished by the recipient laboratory.

The site ID, sample code, and set ID for each sample are recorded on the DDRP Form 101. This form assigns a unique batch/sample number to each soil sample. The shipping form, DDRP Form 102 (see Appendix B), is completed and sent to the laboratories together with the samples. Form 102 uses the batch/sample information from the Form 101 to identify each sample while keeping the category of sample, e.g., audit or routine, unknown to the recipient.

4.2.2.6 Sample Tracking

Sample tracking at the preparation laboratory is initiated with the computer entry of sample receipt information upon delivery of samples to the EMSL-LV cold storage facility. Since the number of pedons to be sampled in the MASS is known before sampling begins, a tally of the pedons received at cold storage can be useful in assessing field sampling progress. As the preparation laboratory raw data are entered into the computer, the QA staff monitors the proportion of samples that have undergone processing and analysis to the total number of samples at the preparation laboratory. In addition, the preparation laboratory entry/verification system is used to track the samples as batches are shipped to analytical laboratories. Sample tracking reports about the sampling, preparation, and analysis phases of the program are prepared for EPA management every two weeks.

4.3 Analytical Laboratory Operations

The sample analysis is conducted by contract analytical laboratories through a series of activities outlined in the following subsections. Specific information on the analytical operations can be found in the ALSOW (USEPA, 1988).

4.3.1 Personnel

Analytical laboratory operations are performed by a group of experienced laboratory analysts under the supervision of a laboratory manager. The manager must have several years of experience in laboratory analysis of soils and has the responsibility of training and supervising the analysts. Each analyst is responsible for specific activities and is required to uniformly enter raw data on specified data forms. The laboratory must employ sufficient personnel to ensure delivery of acceptable data within the time constraints established in the contract.

4.3.2 Laboratory Activities

A brief description of the analytical laboratory activities is provided in the following subsections. Specific information is contained in the ALSOW.

4.3.2.1 Sample Receipt

All samples delivered to a contracted analytical laboratory are checked in by a receiving clerk who: (1) records on the shipping form the date the samples are received, (2) evaluates the condition of the samples received, (3) checks the samples to identify discrepancies with the shipping form, and (4) sends copies of the completed shipping forms to the EPA Sample Management Office (SMO) and the QA manager or designee. If there are any discrepancies or problems such as leakage in shipping or an insufficient amount of a sample, the QA manager must be notified immediately. The receiving clerk retains a copy of the completed Form 102 for the laboratory records. The samples are refrigerated at 4°C as soon as they are logged in and must be kept refrigerated when not in use.

4.3.2.2 Sample Homogenization

The samples received by the analytical laboratories have been air dried and disaggregated to pass a 2-mm sieve at the preparation laboratory. During shipment, the sample material within each container segregates both by particle size and by density; therefore, each sample must be re-homogenized by thorough mixing prior to the removal of aliquots for analysis. Previous research by the QA staff has been useful in specifying the homogenization procedures (Schumacher et al., in preparation)

4.3.2.3 Measurement of Analytical Parameters

Procedures specified in the ALSOW are to be followed exactly for each parameter. Table 4-2 summarizes the parameters to be measured and the corresponding analytical techniques, and Appendix C contains a more detailed description of the parameters.

Table 4-2. Analytical Laboratory Parameters and Corresponding Analytical Techniques

Parameter	Technique[a]
MOIST_A	Gravimetric
SAND (and all fractions)	Sieve/gravimetric
SILT (and all fractions)	Pipet/gravimetric
CLAY	Pipet/gravimetric
PH_H2O, PH_002M, PH_01M	Combination electrode/ millivoltmeter
CA_CL, CA_OAC, CA_CL2	AA or ICP
MG_CL, MG_OAC, MG_CL2	AA or ICP
K_OAC, K_CL, K_CL2	AA or FP
NA_CL, NA_OAC, NA_CL2	AA, ICP, or FP
CEC_CL, CEC_OAC	Autotitration or FIA
AC_BACL	Titrimetric
FE_CL2, FE_PYP, FE_AO, FE_CD, AL_CL2, AL_PYP, AL_AO, AL_CD, SI_AO, AL_CL	ICP
SO4_H2O, SO4_PO4, SO4_0-32	Ion chromatography
C_TOT, N_TOT	oxidation/combustion with IR or TC
S_TOT	oxidation/combustion with IR

[a] AA = atomic absorption spectroscopy
ICP = inductively coupled plasma atomic emission spectroscopy
FP = flame emission photometry
FIA = flow injection analysis
IR = infrared detection
TC = thermal conductivity

4.3.2.4 Contractual Compliance

Before a batch of sample data is submitted to the QA staff for verification, certain completeness and QC requirements must be met. The batch is not considered acceptable for complete payment until these requirements are met (see Section 5.0).

4.3.2.5 Data Entry and Reporting

The raw data generated during sample analysis are entered on a personal computer using a specially designed entry and verification system (see Section 6.2.3.1). Data reports are then generated to assist in the evaluation of data quality.

In addition, the following documents must be updated constantly at the analytical laboratory and must be available, upon request, to the analysts and the supervisor involved in the project:

- Standard operating procedures -- detailed instructions about the laboratory and instrument operations,
- Laboratory QA plan -- clearly defined laboratory protocol, including personnel responsibilities and use of QC samples,
- List of in-house samples -- includes dates for completion of analyses, allowing the analysts to schedule further analyses,

- Instrument performance data -- information about baseline noise, calibration standard response, precision as a function of concentration, and detection limits; used by analysts and supervisor to evaluate daily instrument performance,
- QC charts -- plots of warning and control limits for all quality control check samples (QCCS) and detection limit QCCS (DL-QCCS) generated and updated for each batch; the same QCCS stock solution should be used throughout the term of sample analysis in order to ensure continuity of the control chart. (NOTE: the purpose of preparing QCCS control charts is to ensure that the actual control limits do not exceed the limits defined by the contract),
- QC data report -- a computer printout generated by the laboratory manager that reviews QC results for each parameter; specifies flags (Table 4-3) that are used to document all results outside statistically established QC limits and to identify samples that require reanalysis before data are submitted.

Table 4-3. Laboratory Data Qualifiers

Data qualifier	Indication
A	Instrument unstable
B	Reanalyzed, first reading not acceptable
F	Result outside criteria with consent of QA manager
G	Result obtained from method of standard additions
J	Result not available; insufficient sample volume shipped to laboratory
L	Result not available because of interference
M	Result not available; sample lost or destroyed by laboratory
N	Result outside QA criteria
P	Result outside criteria, but insufficient volume for reanalysis
R	Result from reanalysis
S	Contamination suspected
T	Container broken
U	Result unnecessary, or not required by procedure
X	No sample
Y	[Available for miscellaneous comments]
Z	Result from approved alternative method

Examples of the data reporting forms used by the analytical laboratory are provided in the ALSOW, although examples of certain QE/QC reporting forms are provided in Appendix D. When applicable, data are annotated with the appropriate data qualifiers listed in Table 4-3. Results must be reported to the number of decimal places listed in Table 4-4.

Table 4-4. Decimal-Place Reporting Requirements

Parameter	Reporting units	Decimal Places
MOIST_A	wt. %	2
SAND (and all fractions)	wt. %	2
SILT (and coarse silt)	wt. %	2
CLAY (and fine silt)	wt. %	4
PH_H20, PH_002M, PH_01M	pH units	2
CA_CL, MG_CL, K_CL, NA_CL, AL_CL	meq/100g	3
CA_OAC, MG_OAC, K_OAC, NA_OAC,	meq/100g	3
CEC_CL, CEC_OAC, AC_BACL	meq/100g	3
CA_CL2, MG_CL2, K_CL2, NA_CL2, FE_CL2, AL_CL2	meq/100g	3
FE_PYP, AL_PYP, FE_AO, AL_AO, SI_AO, FE_CD, AL_CD	wt. %	3
SO4_H2O, SO4_PO4	mg S/kg	3
SO4_0-32	mg S/L	3
C_TOT, N_TOT	wt. %	3
S_TOT	wt. %	4

All deviations from the analytical protocols must be documented. All original raw data such as data system printouts, chromatograms, logbooks, individual data sheets, QC charts, and standard preparation data should be retained by the analytical laboratory and be available upon request.

4.3.2.6 Evaluation of Quality Control Data

A data entry and verification system (see Section 6) that is provided to the analytical laboratories includes programs that evaluate the QC data and report the information for each parameter in a summary report. The objective of these summary reports is to keep the QA manager informed of the status of the internal QC checks at the laboratory in order to identify and resolve any problems that may arise. Before laboratories submit a batch of data to the QA staff, all parameters must satisfy the QC requirements outlined in the contract. The laboratory managers are expected to keep the QA manager apprised, on a regular basis, of the evaluation of the QC data either by phone or by sending preliminary data electronically to the QA staff for similar evaluation.

4.3.2.7 Communications

Frequent communications, i.e., two or three contacts each week, are maintained with each analytical laboratory in order to obtain current sample status and to discuss any problems that may occur during analyses. These discussions are to be recorded in a logbook by the QA staff and the laboratory staff. Preliminary and final data are available for access via electronic transfer. The preliminary data are reviewed for anomalies and if a problem is identified, the laboratory is notified. Corrective action or reanalysis may be suggested. Contractual issues are referred to the QA manager and to the contract officer. Major technical issues are referred to the QA manager.

4.4 Sample Custody

Legal chain-of-custody procedures are not required for this study; however, sample custody must be documented. The field crew leader is responsible for all samples in the field as well as the sample shipments. As soil shipments are received in the preparation laboratory, they are immediately logged in and checked against the packing slip and the pedon description forms for proper labeling and quantity. If any discrepancies are found, the soil sampling task leader and the field crew leader are notified. Following receipt of samples, the appropriate laboratory managers are responsible for sample integrity until the samples are archived.

Section 5

Quality Assurance Program

This section describes the MASS QA program which is designed to allow both control and assessment of measurement uncertainty during the sampling, preparation, and analysis phases of the survey.

5.1 Overview of Quality Objectives

The data collection criteria provide a balance between constraints of time and cost and the quality of data necessary to achieve the DDRP research objectives. The MASS QA Plan is designed to accomplish the following general objectives:

- establish the QE/QC criteria used to control and assess data collected in the survey,
- provide standardized sampling, preparation, and analytical methods and procedures,
- utilize assessment samples and procedures to verify the quality of the data,
- perform field and laboratory on-site audits to ensure that all activities are properly performed and that discrepancies are identified and resolved,
- evaluate the data and document the results in QA reports to EPA management.

To aid in this effort, it is necessary to identify both qualitative and quantitative estimates of the quality of data needed by the DDRP data users. Guidelines established by the EPA Quality Assurance Management Staff (Stanley and Verner, 1985) encourage the data users to clearly identify the decisions that will be made and to specify the calculations, statistical and otherwise, that are applied to the data.

The raw data for the DDRP surveys are collected during four major operational phases consisting of mapping, sampling, preparation, and analysis. A certain amount of data measurement uncertainty is expected to enter the system at each phase. Grouping of the data, e.g., by sampling class/horizon configurations, also increases uncertainty. The sampling population itself is a source of confounded uncertainty that is extremely difficult to quantify. Generally, the data quality objectives (DQOs) encompass the overall allowable uncertainty from sample measurement and from the sampling population that the data users are willing to accept in the analytical results (Taylor, 1987). Because of the many confounded sources of uncertainty, overall DQOs for the MASS have not been defined.

This QA Plan focuses on the definition, implementation, and assessment of measurement quality objectives (MQOs) that are specified for the entire sample preparation and analysis phases of data collection as well as for the verification of the field sampling phase. The MQOs are more or less specific goals defined by the data users that clearly describe the data quality that is sought for each of the measurement phases. The MQOs are defined according to the following six attributes:

- Detectability -- the lowest concentration of an analyte that a specific analytical procedure can reliably detect,
- Precision -- the level of agreement among multiple measurements of the same characteristic,
- Accuracy -- the difference between an observed value and the true value of the parameter being estimated,
- Representativeness -- the degree to which the data collected accurately represent the population of interest,
- Completeness -- the quantity of data that is successfully collected with respect to the amount intended in the experimental design,
- Comparability -- the similarity of data from different sources included within individual or multiple data sets; the similarity of analytical methods and data from related projects across regions of concern.

An attempt has been made later in this section to define each quality attribute individually for each measurement phase of the program (sampling, preparation, analysis) or collectively for overall measurement system uncertainty on a parameter-by-parameter basis. The term "uncertainty" is used as a generic term to describe the sum of all sources of error associated with a given portion of the measurement system. In order to reduce measurement uncertainty in the final data values, error occurring in each phase must be identified and rectified during that phase of the survey. Measurement uncertainty for the MASS is controlled through well-defined protocols, system audits, and the introduction of measurement quality samples at each measurement phase.

Initial MQOs were established on the basis of the requirements of EPA data users and on the selection of appropriate methods to obtain the data. The MQOs were reviewed by persons familiar with analytical methods and soil characterization techniques, including soil chemists and laboratory personnel. Modifications to the MQOs and to the protocols were implemented based on information gained from the DDRP Northeastern region and Southern Blue Ridge Province surveys, from peer review comments, or according to the limitations of a particular analytical procedure or instrument.

If the data quality goals cannot be met during the course of the project, the actual level of quality is used to reassess the intended use of the data. A lower than desired attainment of data quality could require different approaches to be used in data analysis or may result in modifications to the levels of confidence assigned to the data.

5.2 Design Characteristics

The design of the DDRP QA Program incorporates the concept of batch sample analysis, where the soil samples collected in the field are combined into groups called batches. Within these batches a series of different types of measurement quality samples are included which are used to evaluate and, possibly, control various types of measurement uncertainty. There are two distinct groups of measurement quality samples used in the MASS design: quality evaluation (QE) samples and quality control (QC) samples. The QE samples allow an independent assessment by the QA staff, while the QC samples enable a laboratory to control measurement error and to meet contractual requirements. In order to assess the MQOs, a series of both types of samples must be analyzed together with the routine samples in a manner that is statistically relevant and in which conclusions concerning the quality of data can be made. There are a number of assumptions upon which this design has been based:

- Complete attainment of the analytical MQOs can be accomplished if each batch meets the within-batch MQOs set for the data quality attributes,
- A two-tiered approach to measuring analytical precision allows the low concentration samples to be assessed separately from the mid-range and high concentration samples; a knot value separates the two tiers and is determined by dividing the precision objective for the lower tier by the precision objective for the upper tier and multiplying by 100,
- Approximately 25 percent of the overall soil analysis effort is applied to the analysis of QE/QC samples required for assessment purposes; normally there are 40 samples in a batch, hence, about 10 of these are measurement quality samples,
- Measurement uncertainty at any given level, e.g., analytical within-batch precision, should be evaluated by the analysis of a minimum of 20 QE samples of any given type; since 30 to 35 batches are expected to be analyzed during MASS, at least one sample used in the evaluation of overall measurement uncertainty is included in each batch,
- The primary sources of measurement uncertainty to be identified, controlled, and assessed are from sampling, preparation, and analysis,

- Each of the primary sources of uncertainty may be considered to be a combination of several smaller sources of uncertainty, e.g., the analytical component can consist of between-laboratory, between-batch, within-laboratory, and within-batch uncertainties,
- Accuracy includes characteristics of audit sample control windows, bias in relation to other laboratories, and trends relative to the accepted "true" value.

To date, it has not been feasible to provide one QE or QC sample type whose entire variability is a reflection of overall measurement uncertainty. However, the combination of two or more different types of measurement quality samples which include the quantifiable components of system measurement uncertainty can provide a reasonable and defensible estimate of overall data quality.

Figures 5-1 and 5-2 graphically illustrate the QE/QC samples that are placed in each mineral or organic batch of analytical samples to determine measurement uncertainty. There are separate analytical within-batch precision MQOs for organic and mineral soils because of the expected wide variability in analyte concentrations. For this reason, mineral and organic samples are organized and analyzed in separate batches.

5.2.1 Quality Evaluation Samples

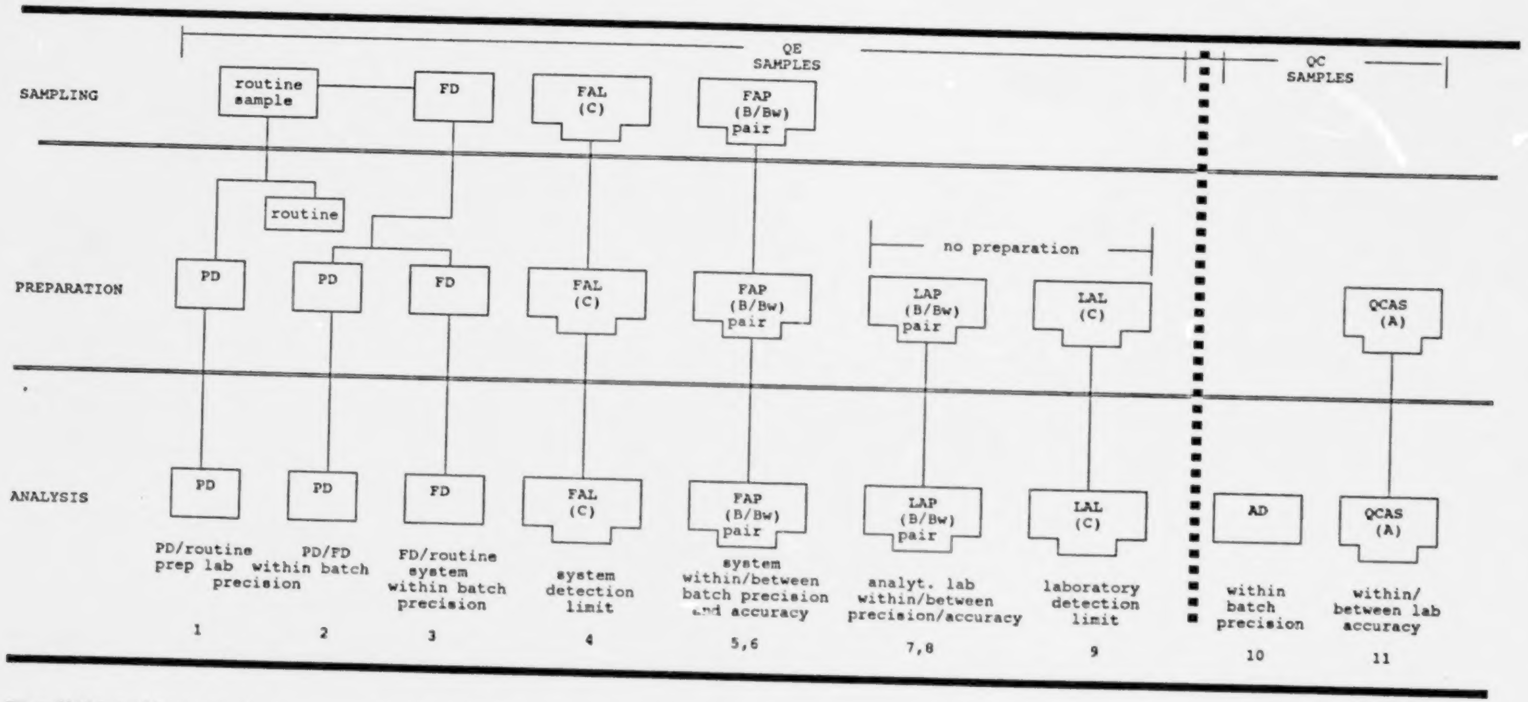
The QE samples are those samples which are known to the QA staff but are either blind or double blind to the sampling crews, preparation laboratory, or analytical laboratory. A blind sample has a concentration range that is unknown to the analysts, whereas a double blind sample cannot be distinguished from a routine sample and has a concentration range that is unknown to the analyst (Taylor, 1987). These samples provide an independent check on the QC process and can be used to evaluate whether the MQOs have been met for any given run or batch, or for all batches, i.e., overall measurement uncertainty. Important characteristics of the QE audit samples include their similarity to routine samples in matrix type and concentration level, their homogeneity and stability, and their defined accuracy windows. Every QE sample has a specific purpose in the data assessment scheme, as described below and in Table 5-1.

5.2.1.1 Field Duplicate (FD) Sample

From every third pedon sampled, a FD sample is collected from a horizon selected at random by the sampling crew leader. The crew places alternate trowels-full of soil into separate bags to produce a pair of samples (one routine, one duplicate) from one specific horizon within a specific pedon. Individual pairs are used primarily to assess the overall within-batch precision. These estimates are pooled to provide the within-batch component of overall system measurement uncertainty.

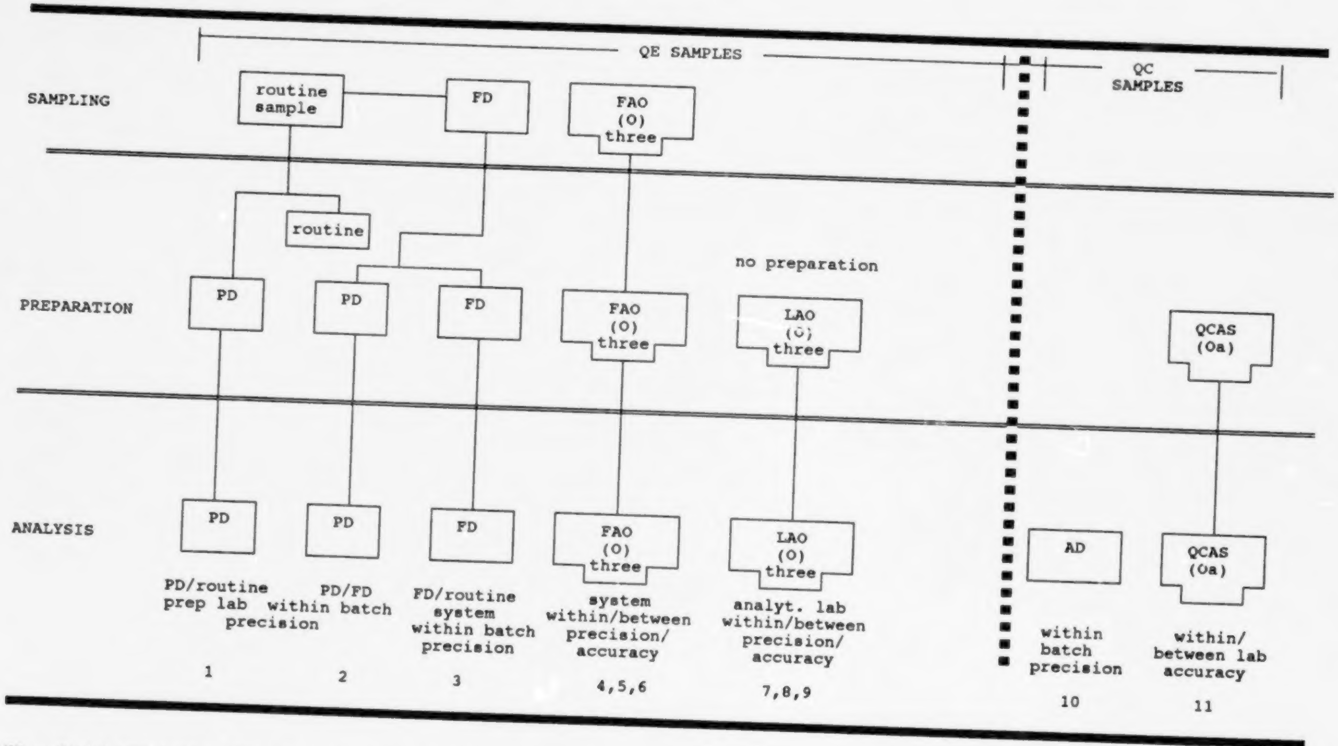
5.2.1.2 Field Audit (FAP or FAO) Sample

The FAP sample is a median-range mineral audit sample sent in pairs by the QA staff to the sampling crews. The FAO sample is a median range organic audit sample sent in triplicate by the QA staff to the sampling crews. The FAP and FAO samples are treated as if they had just been obtained from the excavated pit, i.e., the samples are sieved and bagged during the collection of a FD sample. These samples are then handled as if they were routine samples and undergo all of the associated soil preparation and analysis steps. The FAP and FAO samples are used to identify within-run and within-batch system precision and accuracy for mineral and organic batches, respectively. The variability, i.e., imprecision, is reported as the mean square error by analysis of variance (ANOVA) and the bias, i.e., inaccuracy, is calculated as the difference between an actual measured value and the reference value established by previous DDRP analysis. The analytical data from each pair are also pooled from all batches to provide an estimate of other sources of measurement uncertainty, such as between-batch or between-laboratory system uncertainty.


SAMPLING
PREPARATION
ANALYSIS
QE SAMPLES
QC SAMPLES
routine sample
routine
FD
PD
FAL (C)
FAP (B/Bw) pair
no preparation
LAP (B/Bw) pair
LAL (C)
QCAS (A)
AD
PD/routine prep lab precision
PD/FD within batch
FD/routine system within batch precision
system detection limit
system within/between batch precision and accuracy
analyt. lab within/between precision/accuracy
laboratory detection limit
within batch precision
within/ between lab accuracy
1
2
3
4
5,6
7,8
9
10
11

FD = field duplicate; FAL = low-range field audit; FAP = field audit pair; PD = preparation duplicate; LAL = low-range laboratory audit; LAP = laboratory audit pair; QCAS = quality control audit sample; AD = analytical duplicate.

Figure 5-1. Quality Evaluation and Quality Control Soil Samples for Mineral Batches of the Mid-Appalachian Soil Survey


QE SAMPLES
QC SAMPLES
SAMPLING
PREPARATION
ANALYSIS
routine sample
FD
FAO (O) three
routine
no preparation
PD
PD
FD
FAO (O) three
LAO (O) three
QCAS (Oa)
PD
PD
FD
FAO (O) three
LAO (O) three
AD
QCAS (Oa)
PD/routine prep lab precision
PD/FD within batch
FD/routine system within batch precision
system within/between precision/ accuracy
analyt. lab within/between precision/ accuracy
within batch precision
within/ between lab accuracy
1
2
3
4,5,6
7,8,9
10
11

FD = field duplicate; FAO = field audit triplicate (organic); PD = preparation duplicate; LAO = laboratory audit triplicate (organic); QCAS = quality control audit sample; AD = analytical duplicate.

Figure 5-2. Quality Evaluation and Quality Control Soil Samples for Organic Batches of the Mid-Appalachian Soil Survey

Table 5-1. Status and Assessment of Measurement Quality Samples

Sample type	Status of sample[a]				Assessment purpose[b]			
	QA staff	Sampling crew	Preparation laboratory	Analytical laboratory	System	Sampling	Preparation	Analysis
FAL	K	B	B	DB	D,A	D,A*	D,A*	A
FAP	K	B	B	DB	P,A	P,A*	P,A*	P,A
FAO	K	B	B	DB	P,A	P,A*	P,A*	P,A
FD	–	B	B	DB	P	P,R	P	P
LAL	K	–	–	DB	–	–	–	D
LAP	K	–	–	DB	–	–	–	P,A
LAO	K	–	–	DB	–	–	–	P,A
PD	–	–	B	DB	–	–	P,R	P
QCAS	K	–	–	B	–	–	–	A
MS	K	–	B	–	–	–	A*	–

[a] K = known concentration, B = blind, DB = double blind

[b] D = detectability/contamination, P = precision, A = accuracy, R = representativeness

* For preparation laboratory parameters only

5.2.1.3 Low-Range Field Audit (FAL) Sample

The FAL sample is sent with the FAP samples to the sampling crews by the QA staff and is handled in the same manner as the FAP samples. The FAL is used to identify any system contamination and as an additional check on preparation and system accuracy of mineral soil samples. Pooled data from all FAL samples provide an estimate of the system detection limit (SDL), which is calculated as three times the pooled standard deviation of the FAL samples.

5.2.1.4 Preparation Duplicate (PD) Sample

A pair of PD samples, one split from the FD sample and one split from its associated routine sample, are created at the preparation laboratory immediately following sample homogenization and are placed in each batch. The PDs are used to identify the within-batch preparation uncertainty component of the overall measurement uncertainty and as an independent check on the within-batch precision estimates provided by the analytical laboratories. The samples characterize measurement uncertainty introduced during or after homogenization/subsampling at the preparation laboratory, but do not identify the uncertainty related to sample drying or sieving, or any contamination occurring prior to sample homogenization. The uncertainty attributed to sample preparation is calculated by ANOVA and is derived after identifying and isolating the uncertainty from sample analysis.

5.2.1.5 Laboratory Audit (LAP or LAO) Sample

The LAP samples are mineral audit samples, identical to the FAP samples, that are sent in pairs by the QA staff directly to the preparation laboratory for inclusion in each mineral batch sent to an analytical laboratory. The LAO samples are organic audit samples, identical to the FAO samples, that are sent in triplicate by the QA staff directly to the preparation laboratory for inclusion in each organic batch sent to an analytical laboratory. The LAP and LAO samples are used to assess analytical within-batch precision and accuracy and are used in combination with the FAP and FAO samples to identify sources of bias, e.g., contamination or method error. Comparing the LAP/LAO data across batches allows the QA staff to calculate interlaboratory differences and to assess between-laboratory and between-batch components of analytical measurement uncertainty. The precision components of measurement uncertainty are calculated by ANOVA and the bias is calculated as the difference between an actual measured value and the reference value established by previous DDRP analysis. The LAP/LAO samples are also used to assess between-batch and between-laboratory uncertainty.

5.2.1.6 Low-Range Laboratory Audit (LAL) Sample

The LAL is a low-range natural audit sample, identical to the FAL, that is sent by the QA staff directly to the preparation laboratory for inclusion in each mineral batch sent to an analytical laboratory. When used in conjunction with the FAL sample, the LAL is helpful in calculating instrument detection limits (IDLs) as well as in identifying the magnitude and source of sample contamination. The calculated IDL for a given parameter is estimated as three times the pooled standard deviation of the LAL samples. The IDL is used as an independent check on laboratory detection limits.

5.2.1.7 Manager's Sample (MS)

The MS is a natural audit sample used only at the preparation laboratory that allows the QA staff to independently assess the accuracy of data produced during the preparation laboratory analyses. One MS subsample is placed in each run of analysis and must fall within the control limits established in the sample preparation MQOs.

5.2.2 Quality Control Samples

In order to produce data of consistently high quality, the contract laboratories are required to analyze certain types of QC samples that are known to the laboratory staff and that can be used by the analysts to identify and control analytical measurement uncertainty. Each QC sample has certain specifications that must be met before data for the parameter or batch are accepted, as listed in Table 5-2. The QC samples are non-blind samples procured under contract to assist the laboratories in meeting laboratory MQOs and include both soil samples, e.g., analytical duplicates, and non-soil samples, e.g., reagent blanks. The QC samples are analyzed by each laboratory and allow the laboratory manager and the QA staff to assess whether the physical and chemical analysis is under control. The QC samples used in the MASS are detailed in the following subsections.

5.2.2.1 Quality Control Audit Sample (QCAS)

The QCAS is a natural audit sample provided directly to the analytical laboratories along with the corresponding reference value obtained by previous DDRP analysis. The QCAS is used to control bias and reduce between-laboratory and between-batch components of measurement uncertainty. Data for the QCAS are evaluated by batch on a control chart to ensure that the result are within acceptable accuracy limits as defined by the QA staff. If the QCAS does not meet the accuracy window criteria, the batch of samples is reanalyzed for the parameter in question.

5.2.2.2 Analytical Duplicate (AD) Sample

A duplicate subsample of a specified routine sample, i.e., the 25th sample in each batch, is selected as the AD sample at the analytical laboratory and is used to ensure that within-batch precision MQOs are being satisfied. Precision is calculated as a standard deviation or relative standard deviation, depending on concentration, and is evaluated to ensure that the result is within acceptable limits set forth in the laboratory contract. If the precision objectives for the AD are not met, the batch of samples is reanalyzed for the parameter in question.

5.2.2.3 Calibration Blank

One calibration blank per batch is analyzed immediately after the initial calibration to check for baseline drift. The calibration blank is defined as a zero mg/L standard and contains only the matrix of the calibration standards with no analyte present. During batch sample analysis, a calibration blank is run at the beginning, after every 10 samples, and at the end of each analyzed batch. These calibration blanks are used to check for significant baseline drift and should have values less than the CRDL, except for exchangeable acidity. The within-batch data from the

Table 5-2. Quality Control Requirements for Analytical Batches

Sample Type	Parameter	Requirement
QC audit sample (QCAS)	ALL	Within accuracy window
Analytical duplicate (AD)	ALL	Satisfies precision limits in Table 5-5
Calibration blank		
number run	ALL[a,b]	((samples in batch/10) + 1)
measured	ALL[a,c,d]	≤ CRDL
Reagent blank (mean)	PH_H20, PH_002M, PH_01M SO4_2-16 SO4_32 ALL OTHERS[d]	4.5 ≤ mean ≤ 7.5 ± 3% of theoretical ± 2% of theoretical ≤ CRDL
QC check sample (QCCS)		
number run	ALL	((samples in batch/10) + 1)
measured	SO4_0-32 ALL OTHERS[e]	± 5% of theoretical ± 10% of theoretical
Detection limit QCCS (DL-QCCS)	ALL[a]	± 20% of theoretical
Matrix spike recovery	SO4_0-32 ALL OTHERS[e]	95% ≤ x ≤ 105% 90% ≤ x ≤ 110%
Spike solution	SO4_0 SO4_2-16 SO4_32 CA_CL2	≤ CRDL ± 3% theoretical value ± 2% theoretical value ± 5% theoretical value
Ion chromatography (IC)	SO4_H2O, SO4_PO4, SO4_0-32	Resolution ≥ 60%
Instrument detection limit (IDL)	ALL[a,c]	≤ CRDL
Sample weight	ALL	Measured = ± 5% method
Sample volume	ALL	Measured = method

[a] Except moisture, particle size, and pH parameters
[b] Except SO4_2-32
[c] Except AC_BACL
[d] Except FSI, CLAY, and AC_BACL
[e] Except moisture, particle size, AC_BACL, and SO4_0,4,16 parameters

calibration blanks are used to calculate long-term IDLs.

All calibration standards are prepared as specified in the appropriate procedure. A calibration curve for each analytical method is established by using a minimum of three points within the dynamic linear range. The use of at least a three-point calibration curve is required in place of the manufacturer's recommendations for the instrumentation, unless those recommendations specify more than three points within the linear range. The concentration of standards must bracket the expected sample concentration without exceeding the dynamic linear range of the instrument. The lowest standard should not be greater than 10 times the CRDL. If the concentration of a sample falls outside the range during analysis, the sample is diluted and reanalyzed.

For the MASS, an IDL is defined as three times the standard deviation of at least 15 nonconsecutive calibration blank analyses run on three separate days, based on a similar formula defined by Winefordner and Long

(1983). In some analyses, such as ion chromatography, a signal may or may not be obtained for a blank analysis; in these cases, the IDL is defined as three times the standard deviation of 15 nonconsecutive replicate analyses of a standard whose concentration is four times the lesser of the actual detection limit or the CRDL.

Acceptable initial IDLs must be established prior to any sample analysis. Ongoing IDLs are determined and reported monthly or on a per-batch basis upon batch submission, whichever is more frequent, for all except the moisture, particle size, and pH parameters. The raw data for the initial IDL determinations must be reported to the QA manager. Initial IDLs are valid for one month following their establishment; after this, new IDLs must be established prior to any sample analysis for the first batch of samples. Ongoing IDLs are determined only for those parameters being analyzed during a given reporting period.

After the validity of the initial IDLs has been established, the first batch of samples is analyzed and the IDLs reported for this batch are determined as composites of the calibration blanks from the batch and the calibration blanks run on the second and third day of the initial IDL determination. If a given IDL is invalid, then reanalysis of the batch for the parameter of interest is required. Similarly, the IDLs for other sample batches will be established as composites of the calibration blanks from the batch being analyzed and the calibration blanks from the two previous batches such that the calibration blanks have been determined over three separate days. It is essential that each laboratory analyzes the batches sequentially in order to establish the proper IDL determinations; any exceptions to this practice must be reported immediately to the QA manager.

5.2.2.4 Reagent Blank

When an analytical method requires sample preparation, a reagent blank for each group of samples processed is prepared and analyzed. A reagent blank is defined as a sample composed of all the reagents, in the same quantities, used in preparing an actual sample for analysis. The reagent blank undergoes the same digestion and extraction procedures as an actual sample.

For most parameters, the analyte concentration of a reagent blank must be less than or equal to the CRDL; if not, the source of contamination must be investigated and eliminated. A new reagent blank is then prepared and analyzed, and the same criteria are applied. All samples associated with the "high" blank must be reprocessed and reanalyzed after the contamination has been eliminated. Approximately seven samples and a reagent blank are analyzed prior to the matrix spike and duplicate analyses so that approximate endogenous sample concentrations may be determined.

5.2.2.5 Quality Control Check Sample (QCCS)

Immediately after calibration of an instrument, a QCCS containing the analyte of interest at a concentration in the mid-calibration range is analyzed. The QCCS is analyzed to verify the calibration curve prior to any sample analysis, after every 10 samples, and after the last sample of a batch. The sample must be selected from a stock solution different than that used for the instrument calibration.

The QCCS data are plotted at the laboratory on a control chart, which warns when the concentrations are outside of established QC limits. The same QCCS stock solution must be used to establish all values on a given control chart to ensure continuity. The observed concentration for each QCCS is plotted on the chart and the 95 and 99 percent confidence intervals (warning and control limits, respectively) are developed. The control limits must not differ from the theoretical value by more than the limits given in Table 5-2. A value outside the control limits is considered unacceptable, hence, the instrument is recalibrated and all samples up to the last acceptable QCCS are reanalyzed.

After each day of analysis, the control charts are updated. Cumulative means and new warning and control limits are calculated. If bias for a given analysis is indicated, i.e., at least seven successive points occur on one side of the cumulative mean, sample analysis must cease until an explanation is found and the system is brought under control.

5.2.2.6 Detection Limit Quality Control Check Sample (DL-QCCS)

The DL-QCCS is a low-range QC sample that contains the analyte of interest at concentrations specified in the respective method. The purpose of the DL-QCCS is to eliminate the necessity of formally determining the detection limit on a daily basis. The sample is run once per batch and the measured value must be within 20 percent of the theoretical concentration listed in Table 5-2. If this criterion is not met, the source of error must be identified and corrected, and an acceptable result must be obtained before routine sample analysis is resumed.

5.2.2.7 Matrix Spike Sample

For liquid samples, e.g., cation extractions, one matrix spike sample is prepared for each procedure by spiking an aliquot of a solution with a known quantity of analyte prior to analysis. The spike concentration must be approximately equal to the endogenous level or 10 times the detection limit, whichever is larger. Also, the volume of the added spike must be negligible, i.e., less than or equal to one percent of the sample aliquot volume.

For solid samples, e.g., aliquots for total carbon, one matrix spike sample is prepared for each procedure by adding a known weight of material containing the analyte of interest to a sample of known weight. The spike concentration should be twice the endogenous level or 10 times the detection limit, whichever is larger. The concentration of the matrix spike must not exceed the linear range of the instrument. Although it is not negligible, the weight of the spike material should be considered negligible for the purposes of calculation.

The spike recovery must be within the limits shown in Table 5-2. If these criteria are not satisfied, then two additional (different) samples are spiked with the analyte in question and are analyzed. If the recovery from either sample does not meet requirements, the entire batch must be analyzed by the method of standard additions. The method of standard additions is performed by analyzing the sample, analyzing the sample plus a spike at about the endogenous level, and analyzing the sample plus a spike at about twice the endogenous level. The concentration of the matrix spike sample must not exceed the linear range of the instrument; if this is not possible, the spiked sample is diluted before analysis.

5.2.2.8 Ion Chromatography (IC) Resolution Sample

An IC resolution test is performed once per analytical run by analyzing a standard that contains concentrations of approximately 1 mg/L each for sulfate, phosphate, and nitrate. The analysis is run to provide evidence of "clean" peak separation for proper quantification of each of the sulfate parameters. If the resolution does not exceed 60 percent, the column should be replaced, and the resolution test should be repeated.

5.2.2.9 Internal Duplicate

The internal duplicate is a duplicate subsample used only during the preparation laboratory analyses. It is characterized in essentially the same manner as the AD sample described above. The internal duplicate is helpful in assessing within-run precision during sample preparation.

5.3 Description of Measurement Quality Objectives

The following text describes the data quality attributes and MQOs as they apply to the sampling, preparation, and analysis phases of the MASS. Implementation of the MQOs during the survey is described in Section 6.

The structure of the three analytical MQO tables in this section (Tables 5-3, 5-4, and 5-6) is as follows:

- Parameter -- data variable name of parameter being analyzed (see Appendix C).
- Reporting units -- analytical units in which the laboratory data should be reported.
- CRDL -- contract-required detection limit expressed in reporting units and in parts per million.
- Precision at the lower limit -- a guideline to define the acceptable absolute standard deviation for low concentrations that are difficult to reproduce; a knot, or cutoff value, is reported for which data below the knot are assessed separately from data above the knot.
- Precision at the upper limit -- serves as a guideline to define the acceptable percent relative standard deviation for concentrations above the knot.

5.3.1 Field Sampling and Characterization

Soil sampling includes the physical removal of soil samples from an excavated pit as well as the characterization of the soil pedon and the sampling site. Because the MQOs developed for the analytical operations are not applicable to the sampling activities, specific objectives for soil sampling were developed to ensure that field operations, e.g., sampling site location, profile description, and sampling, are conducted in a consistent manner. The objectives are intended to reduce the errors inherent in collecting soils data and to provide an estimate of the variability among sampling crews.

The goal of the MASS sampling is to describe and collect soil samples from representative pedons of established sampling classes. The classes are intended to represent the soil characteristics of the Mid-Appalachian region. The field sampling produces both qualitative data from pedon characterization, e.g., soil color, and quantitative data from analysis of the soil samples, e.g., soil pH.

5.3.1.1 Precision and Accuracy

Due to the subjective nature of pedon characterization, values for precision and accuracy cannot be determined. However, by the use of multiple descriptions by a number of individuals at the same pedon, variability of descriptions can be assessed. Control and assessment of the pedon characterization are accomplished through various auditing techniques discussed in later sections.

Field sampling precision and accuracy are assessed using data from the QE field samples to estimate the system measurement uncertainty and comparing this uncertainty to that identified in the QE preparation and analytical samples. The field samples are expected to contain the largest amount of confounded error of all QE/QC samples. The MQOs for precision of the physical and chemical analyses of the field samples are presented in Table 5-3. Accuracy is assessed by comparing the laboratory data to the audit window criteria defined for the audit samples. It should be noted that the MQOs for field sampling are not intended to control field sampling error but are used to assess this error and to control within-laboratory error at the preparation laboratory and within- and between-laboratory error occurring at the analytical laboratories.

5.3.1.2 Representativeness

Soil types identified in the Mid-Appalachian region are combined into sampling classes that are known to have, or are expected to have, similar physical and chemical characteristics. Each of the sampling classes can be sampled across a number of watersheds in which they occur. In this approach, a given soil sample does not represent the specific watershed from which it was collected; rather, it contributes to a set of samples which collectively represent a specific sampling class for all watersheds within the sampling region. The sampling crew leader selects a sampling site representing the designated sampling class and vegetation class within the

Table 5-3. Analytical Laboratory Within-Batch Precision Objectives for Field Samples

		CRDL[a]		Precision for mineral samples[b]			Precision for organic samples[b]		
Parameter	Reporting units	units	ppm	SD (lower)	RSD (upper)	Knot	SD (lower)	RSD (upper)	Knot
MOIST_A	wt. %	—	—	0.3	2.5%	12.0	0.3	2.5%	12.0
SAND	"	—	—	6.0	—	—	—	—	—
SILT	"	—	—	6.0	—	—	—	—	—
CLAY	"	—	—	4.0	—	—	—	—	—
PH_H2O	pH units	—	—	0.20	—	—	0.20	—	—
PH_002M	"	—	—	0.20	—	—	0.20	—	—
PH_01M	"	—	—	0.20	—	—	0.20	—	—
CA_CL	meq/100g	0.003	0.05	0.04	30%	0.13	0.20	30%	0.67
MG_CL	"	0.005	0.05	0.04	30%	0.13	0.20	30%	0.67
K_CL	"	0.002	0.05	0.04	30%	0.13	0.20	30%	0.67
NA_CL	"	0.003	0.05	0.04	30%	0.13	0.20	30%	0.67
AL_CL	"	0.007	0.10	0.40	45%	0.89	1.0	45%	2.2
CA_OAC	meq/100g	0.003	0.05	0.04	30%	0.13	0.20	30%	0.67
MG_OAC	"	0.005	0.05	0.04	30%	0.13	0.20	30%	0.67
K_OAC	"	0.002	0.05	0.04	30%	0.13	0.20	30%	0.67
NA_OAC	"	0.003	0.05	0.04	30%	0.13	0.20	30%	0.67
CEC_CL	meq/100g	0.14	1.050[c]	0.50	30%	1.7	0.50	30%	1.7
CEC_OAC	"	0.14	1.050[c]	0.50	30%	1.7	0.50	30%	1.7
AC_BACL	"	0.25	0.005[d]	2.0	45%	4.4	2.0	45%	4.4
CA_CL2	meq/100g	0.005	0.50	0.10	15%	0.67	0.40	15%	2.7
MG_CL2	"	0.0008	0.05	0.01	30%	0.03	0.10	30%	0.33
K_CL2	"	0.0003	0.05	0.01	30%	0.03	0.05	30%	0.17
NA_CL2	"	0.0004	0.05	0.01	30%	0.03	0.05	30%	0.17
FE_CL2	"	0.0005	0.10	0.02	45%	0.04	0.10	45%	0.22
AL_CL2	"	0.0011	0.10	0.10	45%	0.22	0.40	45%	0.89
FE_PYP	wt. %	0.005	0.50	0.06	30%	0.20	0.06	30%	0.20
AL_PYP	"	0.005	0.50	0.06	30%	0.20	0.06	30%	0.20
FE_AO	"	0.005	0.50	0.06	30%	0.20	0.06	30%	0.20
AL_AO	"	0.005	0.50	0.06	30%	0.20	0.06	30%	0.20
SI_AO	"	0.005	0.50	0.06	30%	0.20	0.06	30%	0.20
FE_CD	"	0.002	0.50	0.06	30%	0.20	0.06	30%	0.20
AL_CD	"	0.002	0.50	0.06	30%	0.20	0.06	30%	0.20
SO4_H2O	mg S/kg	0.50	0.025	3.0	30%	10.0	3.0	30%	10.0
SO4_PO4	"	0.50	0.025	3.0	30%	10.0	3.0	30%	10.0
SO4_0-32	mg S/L	0.025	0.025	0.20	15%	1.3	—	—	—
C_TOT	wt. %	0.01	100.0	0.10	30%	0.33	0.10	30%	0.33
N_TOT	"	0.005	50.0	0.03	30%	0.10	0.03	30%	0.10
S_TOT	"	0.001	10.0	0.004	30%	0.01	0.004	30%	0.01

[a] Contract-required detection limit in reporting units and parts per million, respectively.
[b] Within-batch precision by standard deviation below the knot and by percent relative standard deviation above the knot.
[c] For FIA only; for titrations, the value is 0.0075.
[d] Units are meq for this parameter; for organic soils, value is 0.025 meq (1.25 meq/100g in reporting units).

designated watershed according to the sampling protocols. Both the qualitative and quantitative data collected are intended to be representative of soils in the region.

5.3.1.3 Completeness

The sampling completeness objective can be met by ensuring that 100 percent of the designated pedons and their component horizons are sampled, with the exception of certain undecomposed organic horizons, intermittent horizons, or horizons less than three centimeters thick. Only the soil sampling task leader at ERL-C can authorize pedons to be excluded from sampling.

5.3.1.4 Comparability

Soils are sampled and characterized in the same general manner as in previous DDRP surveys. Improvements in methods and the use of consistent sampling protocols and personnel with equivalent experience should provide data of equal or better quality.

5.3.2 Sample Preparation

The goal of sample preparation is to process bulk soil samples collected by the sampling crews and to provide homogeneous subsamples to the analytical laboratories for soil analysis.

5.3.2.1 Precision and Accuracy

A portion of the measurement error incurred at the preparation laboratory is assessed by the inclusion of preparation duplicate samples created during the homogenization/subsampling stage of sample preparation. The samples are used in each batch to assess and, in some cases, control imprecision during this stage of sample preparation. The MQOs for the preparation samples are specified in Table 5-4.

During sample preparation, the precision and accuracy of analysis are estimated by comparing physical and chemical data from the QE field samples (all analyses), the QC internal duplicates (PH_MP, MOIST_P, and OM_LOI only), the clod replicates (BD_CLD), and the known volume replicates (BD_KV). The specific MQOs for precision and accuracy of these samples during the preparation laboratory analysis are outlined in Table 5-5.

5.3.2.2 Representativeness

Laboratory personnel ensure that the integrity of the samples is maintained during the soil preparation activities. Adherence to QC procedures outlined in the PLSOP is monitored by the QA staff. Homogenization of the bulk soil samples allows representative analytical subsamples to be prepared.

5.3.2.3 Completeness

The preparation laboratory is expected to complete the specified analyses and processing tasks for 100 percent of the samples received. Each batch of samples sent to a contracted analytical laboratory must include the specified configuration of routine, duplicate, and QE/QC samples.

5.3.2.4 Comparability

The preparation laboratory processes bulk samples according to protocols documented in the PLSOP. Strict adherence to the protocols should result in comparability of the MASS preparation laboratory with the previous DDRP preparation laboratories.

5.3.3 Laboratory Analysis

The analysis phase of measurement allows the most quantitative evaluation of data quality, as outlined below.

5.3.3.1 Detectability

The data users have determined specific levels of instrument detection for the parameters being analyzed. The contract-required detection limits (CRDLs) for these parameters are listed in Table 5-6. The low concentration QE samples (FAL and LAL) are used to assess contamination issues and to calculate the instrument and system detection limits for specific paramter.

Table 5-4. Analytical Laboratory Within-batch Precision Objectives for Preparation Samples

Parameter	Reporting units	CRDL[a]		Precision for mineral samples[b]			Precision for organic samples[b]		
		units	ppm	SD (lower)	RSD (upper)	Knot	SD (lower)	RSD (upper)	Knot
MOIST_A	wt. %	—	—	0.3	2.5%	12.0	0.3	2.5%	12.0
SAND	"	—	—	3.0	—	—	—	—	—
SILT	"	—	—	3.0	—	—	—	—	—
CLAY	"	—	—	2.0	—	—	—	—	—
PH_H2O	pH units	—	—	0.10	—	—	0.10	—	—
PH_002M	"	—	—	0.10	—	—	0.10	—	—
PH_01M	"	—	—	0.10	—	—	0.10	—	—
CA_CL	meq/100g	0.003	0.05	0.02	15%	0.13	0.10	15%	0.67
MG_CL	"	0.005	0.05	0.02	15%	0.13	0.10	15%	0.67
K_CL	"	0.002	0.05	0.02	15%	0.13	0.10	15%	0.67
NA_CL	"	0.003	0.05	0.02	15%	0.13	0.10	15%	0.67
AL_CL	"	0.007	0.10	0.20	22%	0.91	0.50	22%	2.3
CA_OAC	meq/100g	0.003	0.05	0.02	15%	0.13	0.10	15%	0.66
MG_OAC	"	0.005	0.05	0.02	15%	0.13	0.10	15%	0.66
K_OAC	"	0.002	0.05	0.02	15%	0.13	0.10	15%	0.66
NA_OAC	"	0.003	0.05	0.02	15%	0.13	0.10	15%	0.66
CEC_CL	meq/100g	0.14	1.050[c]	0.25	15%	1.7	0.25	15%	1.7
CEC_OAC	"	0.14	1.050[c]	0.25	15%	1.7	0.25	15%	1.7
AC_BACL	"	0.25	0.005[d]	1.0	22%	4.5	1.0	22%	4.5
CA_CL2	meq/100g	0.005	0.50	0.05	8%	0.62	0.20	8%	2.5
MG_CL2	"	0.0008	0.05	0.005	15%	0.03	0.05	15%	0.33
K_CL2	"	0.0003	0.05	0.005	15%	0.03	0.025	15%	0.17
NA_CL2	"	0.0004	0.05	0.005	15%	0.03	0.025	15%	0.17
FE_CL2	"	0.0005	0.10	0.01	22%	0.05	0.05	22%	0.23
AL_CL2	"	0.0011	0.10	0.05	22%	0.23	0.20	22%	0.91
FE_PYP	wt. %	0.005	0.50	0.03	15%	0.20	0.03	15%	0.20
AL_PYP	"	0.005	0.50	0.03	15%	0.20	0.03	15%	0.20
FE_AO	"	0.005	0.50	0.03	15%	0.20	0.03	15%	0.20
AL_AO	"	0.005	0.50	0.03	15%	0.20	0.03	15%	0.20
SI_AO	"	0.005	0.50	0.03	15%	0.20	0.03	15%	0.20
FE_CD	"	0.002	0.50	0.03	15%	0.20	0.03	15%	0.20
AL_CD	"	0.002	0.50	0.03	15%	0.20	0.03	15%	0.20
SO4_H2O	mg S/kg	0.50	0.025	1.5	15%	10.0	1.5	15%	10.0
SO4_PO4	"	0.50	0.025	1.5	15%	10.0	1.5	15%	10.0
SO4_0-32	mg S/L	0.025	0.025	0.10	8%	1.3	—	—	—
C_TOT	wt. %	0.01	100.0	0.05	15%	0.33	0.05	15%	0.33
N_TOT	"	0.005	50.0	0.015	15%	0.10	0.015	15%	0.10
S_TOT	"	0.001	10.0	0.002	15%	0.01	0.002	15%	0.01

[a] Contract-required detection limit in reporting units and parts per million, respectively.

[b] Within-batch precision by standard deviation below the knot and by percent relative standard deviation above the knot.

[c] For FIA only; for titrations, the value is 0.0075.

[d] Units are meq for this parameter; for organic soils, value is 0.025 meq (1.25 meq/100g in reporting units).

Table 5-5. Preparation Laboratory Within-Run Measurement Quality Objectives

Parameter	Sample type	Reporting format	Expected range	Acceptable accuracy	Acceptable precision
PH_MP	Buffer (QCCS)	0.01 pH units	3.90-4.10	3.95-4.05	—
	Int dup[a]	"	2.50-7.50	—	0.15 SD
	FD	"	2.50-7.50	—	0.20 SD
	FAL (C)	"	4.80-6.00	as specified	—
	FAP (B)	"	4.40-5.40	as specified	0.15 SD
	FAP (Bw)	"	4.70-5.70	as specified	0.15 SD
	FAO (O)	"	3.70-4.50	as specified	0.15 SD
	MS	"	4.10-5.00	as specified	—
MOIST_P	Int dup[a]	0.01 wt. %	0.50-6.00	—	15% RSD
	FD	"	0.50-6.00	—	20% RSD
	FAL (C)	"	0.00-2.50	control limits	—
	FAP (B)	"	1.00-4.00	control limits	15% RSD
	FAP (Bw)	"	1.00-4.00	control limits	15% RSD
	FAO (O)	"	4.00-8.00	control limits	15% RSD
	MS	"	0.50-6.00	control limits	—
OM_LOI	Int dup[a]	0.01 wt. %	0.00-90.00	—	15% RSD
	FD	"	0.00-90.00	—	20% RSD
	FAL (C)	"	0.00-3.00	control limits	—
	FAP (B)	"	5.00-15.00	control limits	15% RSD
	FAP (Bw)	"	1.00-9.00	control limits	15% RSD
	FAO (O)	"	65.00-85.00	control limits	15% RSD
	MS	"	5.00-15.00	control limits	—
RF_FG	FD	0.1 wt. %	0.0-60.0	—	20% RSD **
RF_MG	FD	0.1 wt. %	0.0-60.0	—	20% RSD **
BD_CLD	Reps[b]	0.01 g/cm^3	0.60-2.00	—	20% RSD **
BD_KV	Dups[c]	0.01 g/cm^3	0.40-2.50	—	20% RSD **

[a] The internal duplicate is a replicate subsample that is randomly selected from one soil sample per analytical run.
[b] The replicate bulk density samples are clod samples in which one to three clods per horizon have been sampled.
[c] The duplicate bulk density samples are known volume samples in which one or two samples per horizon are sampled.
** Since these duplicates or replicates are measurements of different samples within the same horizon, variability is anticipated; however, when variability >20% RSD, these samples are checked for possible measurement error.

5.3.3.2 Precision and Accuracy

The MQOs for precision of the physical and chemical analyses of soil samples are presented in Table 5-6. Accuracy is assessed by comparing the analytical data to the audit window criteria defined for the laboratory audit samples (see Section 7.1.3).

5.3.3.3 Representativeness

The integrity of the analytical samples is to be maintained during soil analysis activities. Homogenization of the samples at the preparation laboratory in conjunction with re-homogenization of the samples at the analytical laboratory ensures that a uniform stock of sample is available from which to select aliquots for analysis.

5.3.3.4 Completeness

The completeness objective for all samples collected is 90 percent or better for all analytical parameters. It is possible to attain 100 percent completeness if a sufficient quantity of each sample is available to complete all analyses and reanalyses that may be requested.

Table 5-6. Analytical Laboratory Within-Batch Precision Objectives for Analytical Samples

Parameter	Reporting units	CRDL[a]		Precision for mineral samples[b]			Precision for organic samples[b]		
		units	ppm	SD (lower)	RSD (upper)	Knot	SD (lower)	RSD (upper)	Knot
MOIST_A	wt. %	—	—	0.3	2.5%	12.0	0.3	2.5%	12.0
SAND	"	—	—	3.0	—	—	—	—	—
SILT	"	—	—	3.0	—	—	—	—	—
CLAY	"	—	—	2.0	—	—	—	—	—
PH_H2O	pH units	—	—	0.10	—	—	0.10	—	—
PH_002M	"	—	—	0.10	—	—	0.10	—	—
PH_01M	"	—	—	0.10	—	—	0.10	—	—
CA_CL	meq/100g	0.003	0.05	0.02	10%	0.20	0.10	10%	1.0
MG_CL	"	0.005	0.05	0.02	10%	0.20	0.10	10%	1.0
K_CL	"	0.002	0.05	0.02	10%	0.20	0.10	10%	1.0
NA_CL	"	0.003	0.05	0.02	10%	0.20	0.10	10%	1.0
AL_CL	"	0.007	0.10	0.20	15%	1.3	0.50	15%	3.3
CA_OAC	meq/100g	0.003	0.05	0.02	10%	0.20	0.10	10%	1.0
MG_OAC	"	0.005	0.05	0.02	10%	0.20	0.10	10%	1.0
K_OAC	"	0.002	0.05	0.02	10%	0.20	0.10	10%	1.0
NA_OAC	"	0.003	0.05	0.02	10%	0.20	0.10	10%	1.0
CEC_CL	meq/100g	0.14	1.050[c]	0.25	10%	2.5	0.25	10%	2.5
CEC_OAC	"	0.14	1.050[c]	0.25	10%	2.5	0.25	10%	2.5
AC_BACL	"	0.25	0.005[d]	1.0	15%	6.7	1.0	15%	6.7
CA_CL2	meq/100g	0.005	0.5	0.05	5%	1.0	0.20	5%	4.0
MG_CL2	"	0.0008	0.05	0.005	10%	0.05	0.05	10%	0.50
K_CL2	"	0.0003	0.05	0.005	10%	0.05	0.025	10%	0.25
NA_CL2	"	0.0004	0.05	0.005	10%	0.05	0.025	10%	0.25
FE_CL2	"	0.0005	0.10	0.01	15%	0.07	0.05	15%	0.33
AL_CL2	"	0.0011	0.10	0.05	15%	0.33	0.20	15%	1.3
FE_PYP	wt. %	0.005	0.50	0.03	10%	0.30	0.03	10%	0.30
AL_PYP	"	0.005	0.50	0.03	10%	0.30	0.03	10%	0.30
FE_AO	"	0.005	0.50	0.03	10%	0.30	0.03	10%	0.30
AL_AO	"	0.005	0.50	0.03	10%	0.30	0.03	10%	0.30
SI_AO	"	0.005	0.50	0.03	10%	0.30	0.03	10%	0.30
FE_CD	"	0.002	0.50	0.03	10%	0.30	0.03	10%	0.30
AL_CD	"	0.002	0.50	0.03	10%	0.30	0.03	10%	0.30
SO4_H2O	mg S/kg	0.50	0.025	1.5	10%	15.0	1.5	10%	15.0
SO4_PO4	"	0.50	0.025	1.5	10%	15.0	1.5	10%	15.0
SO4_0-32	mg S/L	0.025	0.025	0.10	5%	2.0	—	—	—
C_TOT	wt. %	0.01	100.0	0.05	10%	0.50	0.05	10%	0.50
N_TOT	"	0.005	50.0	0.015	10%	0.15	0.015	10%	0.15
S_TOT	"	0.001	10.0	0.002	10%	0.02	0.002	10%	0.02

[a] Contract-required detection limit in reporting units and parts per million, respectively.
[b] Within-batch precision by standard deviation below the knot and by percent relative standard deviation above the knot.
[c] For FIA only; for titrations, the value is 0.0075.
[d] Units are meq for this parameter; for organic soils, value is 0.025 meq (1.25 meq/100g in reporting units).

5.3.3.5 Comparability

Analytical data from the MASS are expected to be comparable to the DDRP Northeastern region and Southern Blue Ridge Province (SBRP) soil surveys. Improvements in the analytical protocols could result in data of higher quality than attained in the previous surveys.

Section 6

Quality Assurance Implementation

6.1 Control of Data Quality

The following subsections describe the methods used to control the quality of data produced during the various data collection phases and to ensure that the MQOs described in Section 5 are met.

6.1.1 Field Sampling and Characterization

Control of data quality in the sampling phase requires frequent checks on the crews' compliance with the sampling protocols, as described below.

6.1.1.1 Precision and Accuracy

All prospective field sampling personnel are trained by ERL-C personnel at a workshop held prior to the initiation of sampling. The sampling crew leaders have the responsibility for training personnel that are added to the project after sampling has begun. The staff is encouraged to hold an additional hands-on training session for all sampling crew members, although this session is optional. Further ensurance of precision and accuracy in sampling is accomplished with independent pedon descriptions.

A representative of the Soil Conservation Service (SCS) state soils staff independently describes a minimum of one pedon per sampling crew. The soil profile is described on the same face of the soil pit as described by the sampling crew. The state office representative (SOR) makes the assessment while the crew is describing and sampling the pedon.

The Regional Coordinator/Correlator (RCC) must be a qualified soil scientist with several years experience in soil profile description, mapping, and correlation. The RCC performs an independent profile description at least once for each sampling crew. At least one site in each state is monitored with the SOR; the remaining pedons may be monitored independently. The RCC also ensures that the SORs perform independent profile descriptions.

The independent pedon descriptions are used to assess the variability in site descriptions among soil scientists. Because the pedon can be characterized anywhere along the pedon face, this information cannot be used to evaluate the accuracy of characterization at a specific point, e.g., soil color at a specific location, but it can be used to evaluate the general variability of independent pedon characterization.

6.1.1.2 Representativeness

Soil sampling information provided on the field data forms is used to determine whether the pedons sampled are within the range of morphological characteristics that identify the respective sampling classes. Data are analyzed by ERL-C staff to determine the population characteristics of the sampling classes.

6.1.1.3 Completeness

Soil sampling protocols specify the sampling of 100 percent of the designated pedons and their corresponding horizons. If samples are lost, spilled, or mislabeled, it may be possible to return to the same site and resample the pedon. If a sampling site is inaccessible, the reason for excluding the site must be formally documented by the sampling crew and immediately reported to the ERL-C soil sampling task leader and QA auditor via the SOR and RCC.

6.1.1.4 Comparability

The consistent use of standard NCSS methods, specified protocols, and forms for the sampling phase provides field and analytical data that are comparable to data generated from other studies which have used these standardized methods. Specifically, the MASS data are expected to be comparable to data collected during the DDRP Northeastern region and SBRP soil surveys.

6.1.2 Sample Preparation

Control of data quality during sample preparation requires frequent checks of the laboratory's ability to comply with the protocols.

6.1.2.1 Precision and Accuracy

The preparation laboratory combines sets of routine and QE/QC soil samples into batches, each containing approximately 40 samples. After processing a FD sample and its associated routine sample, two subsamples are split out of each sample and are included in a batch as the PD/FD and PD/routine pairs. Comparison of physical and chemical data from each pair allows evaluation of preparation within-batch precision. Since the precision data for some of these samples are evaluated before soil preparation is completed, the data may be used to control preparation laboratory uncertainty.

As data from the physical and chemical analyses become available, the preparation duplicates are evaluated in terms of the MQOs listed previously in Table 5-4. Reanalysis of soil parameters at the analytical laboratories may be justified on the basis of data from the preparation duplicates. If reanalysis confirms the original values, the sample preparation phase may be a suspected source of error.

The analyses that take place at the preparation laboratory must satisfy the precision and accuracy criteria, previously outlined in Table 5-5. If the QE/QC objectives are not met, the data undergo confirmation and the affected run of samples may be reanalyzed as specified in the PLSOP (Bartling et al., 1988).

The preparation laboratory manager is responsible for providing the QA manager with bi-monthly reports summarizing the progress of sample preparation. These reports address issues relating to the tracking of samples and any QC discrepancies with the resulting data.

6.1.2.2 Representativeness

Each bulk soil sample is processed by a preparation laboratory in order to produce a thoroughly homogeneous sample. Homogenization is accomplished by passing the sample through a Jones-type riffle splitter at least five times in succession. The riffle splitter is subsequently used for subsampling homogeneous analytical samples. All samples not being processed are stored at 4°C in the preparation laboratory. Because the FD samples are collected according to a random selection method, it is assumed that the PD samples split from the FD/routine pair (see Section 5.2.4) are representative of the ranges of concentration for the MASS routine soil samples. This aspect of representativeness is assessed by the Kolmogorov-Smirnov test (Conover, 1980).

6.1.2.3 Completeness

All soil samples that satisfy the preparation laboratory sample receipt criteria are processed and analyzed as specified in the PLSOP. One pair of FAP samples and one FAL sample (or three FAO samples), one pair of FD/routine samples, and one pair of LAP samples, one LAL sample (or three LAO samples), two pairs of PD/routine samples, one QCAS, and appropriate sets of routine samples are grouped into approximately 40 samples per batch.

6.1.2.4 Comparability

By adhering to the PLSOP, sample preparation should be comparable to that of the DDRP Northeastern region and SBRP soil surveys. System audits and periodic routine audits are undertaken by appropriate QA representatives to ensure consistent laboratory performance. The MQOs for analysis within the preparation laboratory, as well as MQOs for the PD samples, are used to assess and control measurement uncertainty affecting comparability of the data.

6.1.3 Laboratory Analysis

Before an analytical laboratory is awarded a contract to analyze samples, the laboratory must demonstrate its ability to meet certain requirements relating to on-site facilities, instrumentation, personnel, and the production and quality of data. Analytical laboratories respond to an invitation for bid (IFB) and are sent copies of the ALSOW, which contains all contractual requirements including the methods for soil analysis. A group of pre-award performance evaluation (PE) soil samples, consisting of characterized audit samples used in previous DDRP surveys, is sent to the participating laboratories for analysis. Each laboratory is rated according to the pre-award scoring evaluation sheet (see Appendix E). Laboratories that submit the lowest bids and pass the PE criteria are then observed during a pre-award audit visit (see Appendix F), leading to a final selection of contract laboratories by EPA management.

6.1.3.1 Detectability

The analytical laboratories are required to make repeated determinations of the IDLs before analysis begins. The IDLs serve as an estimate of the lowest concentration of an analyte that an instrument can reliably detect. In addition, the laboratories must satisfy the CRDLs outlined previously in Table 5-2 and are required to demonstrate with control charts that the analytical system is under control at all times during analysis. The data derived from the DL-QCCS, FAL, and LAL samples are used in assessing these objectives and in calculating IDLs and SDLs.

6.1.3.2 Precision and Accuracy

Upon the satisfactory completion of the contractual requirements by the analytical laboratories, a data package for each batch of samples is submitted to the QA operations staff for evaluation. The data are verified and evaluated in accordance with the precision and accuracy MQOs for the various QE/QC samples and with the appropriate soil chemistry relationships described later in this section. Precision for each type of assessment sample must meet the objectives outlined previously in the MQO tables of Section 5, insofar as the objectives relate to the confirmation/reanalysis considerations outlined later in Section 6.2. Data from the LAP/LAO and LAL samples must fall within the accuracy windows defined by the QA staff and data users. Reanalysis may be requested for certain parameters or batches on the basis of imprecise or inaccurate results from the assessment samples.

6.1.3.3 Representativeness

Upon receipt of each analytical sample from the preparation laboratory, the analysts are required to re-homogenize the soil thoroughly to ensure the representativeness of aliquots used in the analyses. All samples not in use are stored at 4°C in the analytical laboratory.

6.1.3.4 Completeness

The completeness objective for all samples collected is 90 percent or better for all parameters. A level of 100 percent completeness is possible if a sufficient amount of all samples is available to complete all routine analyses and reanalyses.

6.1.3.5 Comparability

Comparability is assured by the uniform use of procedures documented in the SOW and by the use of uniform reporting units as specified on the data summary forms. The QA procedures specified for the analytical laboratories allow for the determination of measurement uncertainty so that the results can be compared between laboratories. In addition, the analytical methods used in the survey can be compared to methods used in the other DDRP surveys.

6.1.4 On-Site Systems Audits

A major factor in controlling data quality is the independent on-site systems audit, which ensures that all of the survey participants are adhering to the protocols in a consistent manner. The on-site field and laboratory audits are described below.

6.1.4.1 Sampling Crews

The sampling crews are audited by three separate individuals: the SOR, the RCC, and the QA field auditor.

The SOR audits a minimum of one pedon per sampling crew. The SOR monitors adherence to protocol for site selection, sample collection, and sample labeling. Written reviews are submitted to the soil sampling task leader at ERL-C within two weeks. Major discrepancies are reported verbally within two working days. The RCC monitors one site per sampling crew for adherence to National Cooperative Soil Survey (NCSS) standards and the MASS sampling manual (Kern et al., 1988). During the audit the RCC identifies, discusses, and resolves any significant discrepancies. The RCC and SOR discuss the independent pedon descriptions and inform the sampling crew leader during sampling of any major deviations from the protocols that could affect the quality of samples that are collected. Written reports are submitted to the soil sampling task leader at ERL-C within two weeks and the resolution of major problems is reported verbally within two working days.

The QA field auditor evaluates each sampling crew at least twice to ensure adherence to the sampling protocols. These audits are intended to evaluate and clarify the site selection, profile description, and soil sampling procedures. A detailed sampling questionnaire is used in the evaluation (Kern et al., 1988). Written reports are submitted to the soil sampling task leader at ERL-C within two weeks and major discrepancies are reported verbally within two working days. The field auditor is responsible for coordinating the overall QA sampling program and for resolving any major issues. The auditor ensures that all sampling crews receive consistent instructions and clarifications of the protocols.

The QA auditor conducts an in-depth review of all field operations for compliance with the sampling protocols. This includes interviewing the sampling crew members while accompanying the crew on a sampling excursion. If there are any discrepancies, the QA auditor must attempt to correct them by reference to or by interpretation of the sampling protocols. The soil sampling task leader is responsible for conveying information concerning major issues to the DDRP technical director.

6.1.4.2 Preparation Laboratory

The preparation laboratory can expect a minimum of two on-site system audits. The first on-site audit is performed before initial receipt of samples in order to assess the facilities, including the cold storage unit and the sample drying and processing areas. The questionnaire in Appendix I is used in this evaluation. The QA auditor discusses any discrepancies with the preparation laboratory manager. All observations are summarized in an audit report that is submitted to the QA manager within two weeks following the audit visit.

The second on-site audit is conducted approximately one-third of the way through sample processing. After reviewing the initial audit report, any changes made since the first audit are noted on the questionnaire. Also, any additional discrepancies identified must be corrected and brought to the attention of the QA manager. A summary report is written for this and any additional on-site visits and is submitted to the QA manager within two weeks following the audit.

The QA staff also conducts periodic audits to inspect the facilities and to assess the data entry and verification activities. Reports are submitted to the QA manager on a regular basis.

6.1.4.3 Analytical Laboratory

Each analytical laboratory can expect a minimum of two on-site audits. The first onsite evaluation is performed after the laboratory has successfully analyzed the PE samples. The QA auditor conducts an in-depth review of all laboratory functions that are pertinent to the analyses. The questionnaire in Appendix F is used to document the on-site laboratory audit. The QA auditor brings any problems to the attention of the laboratory manager for corrective action. All observations are summarized in an evaluation report that is submitted to the QA manager within two weeks following the audit visit.

The second on-site audit is conducted approximately one-third of the way through sample analyses. All changes that have been implemented since the initial audit are reviewed. Data from the QE/QC samples received to date are assessed. An evaluation report is written for this and any subsequent on-site audits and is submitted to the QA manager within two weeks following the audit visit.

6.2 Data Verification

The intent of this subsection is to describe the various mechanisms that are used in defining and implementing the data verification procedures and the corrective actions that are taken if the MQOs are not satisfied.

6.2.1 Field Sampling and Characterization Data

Verifying the quality of the soil characterization data entered on the SCS-SOI-232 field data form (see Appendix A) is a task that requires a large reference base of information, which includes the field data form entry codes and a series of NCSS resource handbooks, e.g., the Soil Survey Manual (USDA/SCS, 1981). Some entries are checked against logbooks or analytical laboratory data and other entries are compared with soil taxonomic criteria. Certain general field characteristics may not be possible to verify.

The field data forms are double-entered into a personal computer data file upon receipt of the forms from the sampling crews via the preparation laboratory manager. A computer program designed to check every entry on the form verifies the field data (see Appendix G). The program checks for appropriate coding and completeness of entries. Exception programs examine the internal consistency of the field data and compare related field parameters, e.g., soil texture modifier versus percent rock fragments, or compare field and analytical parameters, e.g., field pH versus laboratory pH. In addition, certain entry fields on the first page of the field data form are manually checked for completeness and correctness using the pedon code and site identification information provided by ERL-C personnel.

The program appends the discrepant data with appropriate field data verification flags. A form listing the discrepancies (see Appendix G) is sent to the SCS state office representative or the appropriate sampling crew leader for evaluation. The sampling crew checks the discrepancy form against the field data form and logbook, corrects the questionable entry, signs the discrepancy form, and returns the form to EMSL-LV. The form is used by the QA staff to edit the local working copy of the raw data base.

When all of the field data forms have been properly edited, a final run of the verification program is performed on the field data bases to flag any remaining anomalies.

6.2.2 Preparation Laboratory Data

A computer program has been developed that allows entry and verification of preparation laboratory data from the raw data forms shown in Appendix B. The program also tracks soil samples through the various sample processing and analysis activities, and assigns verification flags to discrepant data. A remote modem assembly allows concurrent assessment by the QA staff. A summary of the preparation laboratory verification procedures and flags is presented in Appendix H.

After the laboratory analysts enter raw data on the forms, an evaluation procedure is initiated which identifies coding discrepancies and those data that do not satisfy the MQO criteria previously outlined in Table 5-5. The flags identified in Appendix H are used to qualify the discrepancies. All outliers must be confirmed or corrected before the data are assigned to the verified preparation laboratory data base.

The summary data form (DDRP Form 101) is reviewed by QA staff to ensure that the sample codes correspond to those entered on the field data and raw data forms. The inclusion of appropriate QE/QC samples is checked and recorded for each batch. Analytical data are checked for completeness and correctness. The preparation laboratory manager is instructed to acknowledge and correct any errors in the data while reviewing the raw data forms, control charts, or logbooks. The shipping form (Form 102) is compared with the Form 101 to verify the analytical laboratory destination and the number of samples shipped. The data base manager is notified by QA staff of any changes made to the data base as a result of these checks. The appropriate analytical laboratory and the EPA Sample Management Office (SMO) are notified of any changes affecting sample analysis or data reporting. All interactions with the laboratories, ORNL, SMO, and ERL-C staff are recorded in a logbook.

Corrective action for the preparation laboratory is accomplished primarily through the application of a QA reanalysis template (QART) for each analysis of interest (see Appendix J). The QARTs provide an assessment checklist of QE/QC samples for each analytical run. The templates are used to make decisions on whether to request reanalysis of a particular parameter and are designed to assess data on the basis of precision limits and accuracy windows.

The QARTs are constructed as spreadsheets, where the row entry fields specify the evaluation criteria and the column entry fields represent the magnitude of the measurement uncertainty that has occurred. The first column is used to identify major measurement uncertainty and the second column identifies minor uncertainty. When major uncertainty occurs, the QA manager informs the preparation laboratory manager to check for errors in the data for the suspect run and parameter before initiating reanalysis. If the laboratory confirms the values, then reanalysis may be requested for all samples in the run. The following types of measurement uncertainty are considered major for all parameters measured at the preparation laboratory and constitute the basis for requesting confirmation/reanalysis:

- Precision/accuracy -- The pair of FAP samples and the FAL sample (or the triplicate of FAO samples) are grouped to allow three evaluations. The FAPs and FAOs are evaluated for precision and accuracy, and the FAL is evaluated for accuracy. Major uncertainty exists if any two of these three evaluations fail to satisfy the MQOs.
- QCCS -- Major uncertainty exists if a QCCS is outside of control limits.
- Cumulative minor uncertainty -- If three or more instances of minor uncertainty occur, this is considered to be comparable to major uncertainty.

The following types of measurement uncertainty are considered minor for all parameters measured at the preparation laboratory:

- Precision/accuracy -- Minor uncertainty exists if one of the three precision/accuracy evaluations do not satisfy the MQOs, or if the FDs, internal duplicate, or manager's sample do not satisfy the MQOs.

6.2.3 Analytical Laboratory Data

The analytical data verification is a multifaceted, computerized approach to provide a concise and consistent assessment of the data. The overall program is highlighted by the Laboratory Entry and Verification Information System (LEVIS); characteristics of the system and related programs are described below.

6.2.3.1 Laboratory Entry and Verification Information System (LEVIS)

The LEVIS programs are implemented on personal computers and facilitate the data entry and QC sample evaluation at the analytical laboratories as well as the evaluation of laboratory performance by the QA staff. The system is a menu-driven product that is designed as a two phase operation, where phase one is an analytical laboratory system and phase two is a quality assessment system.

Phase one is implemented on computers supplied by the EPA to each of the analytical laboratories and linked to a central EPA computer located at EMSL-LV. This phase includes the data entry system and the two laboratory components of the verification system: the QC summary reports and the soil chemistry relationships. Phase two is implemented only on the central EPA computer and incorporates two additional verification programs to assess QE samples for accuracy and precision. This phase first converts the phase one data base files to the phase two data base structure before evaluation programs are run. The central maintains data from all of the analytical laboratories.

Communications software has been selected that allows the transfer of data files from the laboratories to the central computer. The software selected for this operation is *PC Anywhere*, produced by Dynamic MicroProcessor Associates. The software allows the central computer to operate as a remote terminal to the laboratory computer when both are connected by a modem. Commands typed on the central computer are executed on the laboratory computer, allowing the QA staff to review a laboratory's data files, run programs, and transfer data to the central computer.

The entire LEVIS system must be accessible through the menus by selecting options displayed on the screen. The three laboratories must operate independently with little support from the QA staff; therefore, self-explanatory menus to guide the user are utilized. Color menu screens are implemented in phase one and two to help highlight options and screen information.

Several key analytical laboratory personnel normally participate in the training, including the laboratory manager, analysts, and data entry operators. To aid in training and support, a LEVIS User's Guide has been prepared (SAIC, 1988) and a "test" batch of data is installed on each computer to evaluate the verification procedures.

LEVIS phase one facilitates the entry of the analytical results including all raw data, e.g., extract volume, collected during sample analysis. The calculation of the final data, including the conversion of instrument readings to reporting units and correction for moisture content, is performed by the system. The LEVIS design also facilitates the output to hard copy printouts of the data files for further review. Hard copies are made of the input data files and checked against the laboratory data sheets by the data entry personnel. The laboratory manager is required to review the hard copy outputs.

The analytical laboratories generally operate as follows: 1) perform soil analysis; 2) enter results into LEVIS; 3) review data and correct errors, if necessary; 4) perform and evaluate verification checks; 5) reanalyze if necessary (repeat previous steps); 6) select appropriate run for submission if reanalysis is performed; 7) submit data to QA staff. This process is repeated for each parameter until the entire batch is complete for all parameters and ready for formal submission. The QA staff transfers preliminary data by modem and phase two verification programs are run by the QA staff to evaluate the data for possible discrepancies. Formal submission data are sent by the laboratories on floppy disk.

6.2.3.2 Verification of Batch Data

Using the LEVIS system, the preliminary data undergo a review against the phases one and two criteria. Instructions are given to the laboratory concerning the samples requiring confirmation of the reported values or reruns of the existing extract solutions; re-extraction normally is not performed at this time. If there is no extract solution remaining, the laboratory informs the QA manager and awaits further instructions. If results change during confirmation, the laboratory is instructed to re-enter the correct data into their LEVIS system and send EMSL-LV a new floppy and hard copy submission of the data. If confirmation fails to correct the discrepancies, then reanalysis of the batch is requested for the parameter of interest.

Upon concluding the batch sample analysis, some data values may still have QE/QC outliers or other discrepancies. The affected samples can possibly be grouped into a separate reanalysis batch. The samples are re-extracted and the results from this second round of analysis are reviewed and, where appropriate, edited into the data base.

6.2.3.3 Verification by Internal Consistency Checks (ICCs)

An internal consistency program is used, apart from LEVIS, to generate routine data outliers in each batch. Analytical data from each parameter are correlated against corresponding data from all other analytical parameters measured in the MASS. For each parameter, the parameter pair with the strongest linear relationship, based on the coefficient of determination (r^2), is identified.

Correlations are not performed on parameters within the same extract or from the same measurement. For example, calcium values from the ammonium acetate extract are not correlated with magnesium values from the ammonium acetate extract, even though the resulting r^2 value might have the highest correlation. The reason for this approach is that certain errors, e.g., incomplete extraction, would not be identified by performing correlations within the same extracting solution.

The ICCs are performed by using a weighted linear regression model (SAS, 1986) because previous DDRP data have exhibited heteroscedasticity, i.e., the variances are not the same for the entire population. The weighting factor (w) used in the regression is calculated as the reciprocal of the analyte concentration of the independent variable ($w = 1 / x$). The weighting is not performed on logarithmically defined parameters such as soil pH. A correlation is run by plotting values for one parameter on the X-axis and values for another parameter on the Y-axis. The X- and Y-axes of each parameter then are reversed and the regression is repeated.

The results from both regressions are combined in order to identify the outliers, which are defined as those points having a studentized residual (Belsley et al., 1980) of 3.0 or higher. The studentized residual is an appropriate robust technique, although one possible limitation of the approach is that the outlier itself may strongly influence the regression estimates of the slope or intercept, thereby affecting the value of the residual. In this event, an application of the DFFITS statistic (Belsley et al., 1980) can measure the change in the predicted value resulting from the exclusion of a specific observation in the regression analysis. The DFFITS statistic is used to examine the significance of large differences in residuals. As with the studentized residual, division by the estimated error normalizes the statistic to allow comparison among points of varying precision. As a result, controlling data points that might unduly affect the predicted value of the dependent variable tend to have a high DFFITS value. The critical point used to define a high value is the "critical" DFFITS.

A data outlier is identified as any data point exceeding the critical values defined for the studentized residual and the DFFITS statistic. These points are temporarily removed from the set of observations being analyzed. Using the remaining data, a second regression is performed on the same parameters. Utilizing the regression equation, i.e., slope and intercept, from the second regression and the mean and corrected sum of squares from data points defined as outliers in the first regression, a residual test is performed that examines and returns certain outliers to the set of "good" or viable data points. Any outliers failing this test are considered "true" outliers and undergo additional tests to assess their validity. Results are checked for accuracy in transcription against the values in the data package and, where necessary, corrections are made.

The purpose of these evaluations is to identify routine values for each analytical parameter that are not consistent with the majority of values observed. These values are checked for errors in transcription, data entry, or editing. If no discrepancies are encountered, these data values are confirmed by the analytical laboratory. In the event that more than 10 outliers occur in any one batch, reanalysis may be requested. Five to 10 outliers are considered a minor problem but may be used with other criteria to justify reanalysis.

6.2.3.4 Verification with Soil Chemistry Relationships (SCRs)

The SCRs are another tool used to examine the internal consistency of the routine sample data (see Appendix D). It is expected that approximately 10 percent of the data will not comply with these relationships; these anomalous data are examined by a staff soil chemist who either qualifies them or assigns appropriate flags signifying the discrepancy (see Appendix K).

Data flow for the SCRs uses a separate LEVIS menu selection, where each program is selected to run independently, i.e., the menu selection does not automatically run all the SCRs at the same time, although that option is available. The output reports are then reviewed by the laboratory personnel, and the raw data for samples that do not meet the criteria are flagged and then reviewed in order to identify errors with sample codes, data entry, dilutions, parameters, or other factors. Any discrepancies that can be corrected are edited into the data base, and the QC summary checks and SCRs are run through the program again.

If six or more outlying values from one batch occur for any given SCR, the QA staff reviews all data relating to the batch to determine whether there is the possibility of sample contamination or other systematic source of error. If the outliers cannot be explained with this approach, reanalysis is requested for the parameter of interest. If one to six outlying values occur, a minor discrepancy is identified and may be justification for reanalysis if other batch-wide discrepancies are noted.

6.2.3.5 Quality Assurance Reanalysis Templates (QARTs)

The analytical QARTs provide an assessment checklist of QE/QC samples, ICCs, and SCRs for each batch of data. The templates are used to make decisions on whether to request a batch-wide reanalysis of a particular parameter from an analytical laboratory. The QARTs are designed to assess data on the basis of precision limits, accuracy windows, ICCs, and SCRs (see Appendix J).

The QARTs are constructed as spreadsheets, where the row entry fields specify the evaluation criteria and the column entry fields represent the magnitude of the measurement uncertainty that has occurred. The first column is used to identify major measurement uncertainty and the second column identifies minor uncertainty. When major uncertainty occurs, the QA manager informs the analytical laboratory to check for errors in their data for the parameter and batch in question prior to initiating reanalysis. If the laboratory confirms the values, then reanalysis of the parameter in question is requested for all samples in the batch. The following types of measurement uncertainty are considered major for all parameters and constitute the basis for requesting confirmation/reanalysis:

- Precision/accuracy -- the two pairs of PD/routine samples, one pair of LAP samples, and one LAL sample are grouped to allow four evaluations. The PDs are evaluated for precision, the LAPs are evaluated for precision and accuracy, and the LAL is evaluated for accuracy. Major uncertainty exists if any two of these four evaluations fail to satisfy the MQOs.
- Internal consistency checks -- Major uncertainty exists if more than ten values from a batch are outlying for a given parameter.
- Soil chemistry relationships -- major uncertainty exists if six or more SCRs fail within a batch.

- Cumulative minor uncertainty -- if three or more instances of minor uncertainty occur, this is considered to be comparable to major uncertainty.

The following types of measurement uncertainty are considered minor for the purposes of establishing reanalysis criteria:

- Precision/accuracy -- Minor uncertainty exists if one of the four precision/ accuracy evaluations do not satisfy the MQOs, or if the FDs or FAPs do not satisfy the MQOs.
- Internal consistency checks -- Minor uncertainty exists if five to ten values in a batch are considered outlying for a given parameter.
- Soil chemistry relationships -- Minor uncertainty exists if one to six values fail within a batch.

Section 7

Data Quality Assessment and Reporting

This QA plan has defined the MQOs (see Section 5) and described the implementation of the QA program for the MASS (see Section 6). This section describes the statistical assessment procedures that are applied to the data and the general assessment of the data quality accomplishments. Reports to EPA management are also discussed.

7.1 Statistical Design

7.1.1 Assessment of Detectability

The assessment of detection limits is accomplished on a parameter basis at four levels: 1) compliance with CRDLs; 2) calculation of actual IDLs; 3) calculation of estimated SDLs; and 4) identification of routine samples having concentrations below the SDL. The results can be grouped in tabular form to allow comparisons among the values for any parameter of interest.

7.1.2 Assessment of Precision

A statistical evaluation procedure that has been developed by the QA staff and data users is applied to the data in order to assess possible uncertainty stemming from confounded data collection imprecision. An additive model is used, where an observed value of any soil characteristic is considered as the sum of the "true" or accepted value and an error term. This model assumes that data uncertainty is directly related to the error variance (Miah and Moore, 1988).

In the DDRP surveys, the error variance is dependent upon the "true" value of the soil characteristics of interest. Because of the wide range of analyte concentrations for the soils, it is necessary to separate the concentration range into segments of error variance that serve as estimates of data measurement uncertainty. The MASS statistical approach, therefore, requires the entire analytical concentration range to be partitioned into several intervals not necessarily of equal length. An assumption is made that the error variance within each interval is independent of, and changes with, the "true" analyte concentration.

Within this framework, the error variance is represented by a step function (Rudin, 1974) where each step value is the error variance for a specific defined interval. A pooled estimate of the error variance is obtained by taking a weighted average of the individual step values, using the corresponding degrees of freedom as the weighting characteristic.

A fundamental difficulty is assessing the effect of the error variances on the routine sample data. A measure of this effect, delta, is estimated by averaging the step values of the error standard deviation, using the proportion of routine samples in each interval as the weighting characteristic (Van Remortel et al., 1988). Since data collection is a multiphase process and uncertainty accumulates in the data with each progressing phase, the cumulative uncertainty is estimated with the delta values using the QE/QC data.

7.1.3 Assessment of Accuracy

The accuracy windows for the laboratory audit samples are based on previous interlaboratory analyses of the same sample material by the same protocols. The objective of setting windows is to specify a range of acceptable single values based on a mean and standard deviation computed from a number of previously observed values. The prediction intervals used for the accuracy windows are generally determined by robust estimation using a biweight procedure (Kafadar, 1982). If the standard biweight approach produces windows that are too wide to accommodate the data requirements of the DDRP data users, a MQO-based confidence interval around the biweight-generated mean is used.

The known accuracy windows for these samples are used in deciding when a particular sample is outside of control limits. The mean of a LAP/LAO pair or triplicate is used in lieu of an individual sample.

7.1.4 Assessment of Representativeness

The sampling aspect of representativeness is assessed by comparing the individual site and pedon classifications with the component sampling classes to which the soils are assigned. Soils that fall outside the range of characteristics of their respective sampling class would be considered non-representative.

Representativeness of the measurement quality samples is assessed by comparing the concentration ranges of data from the FD and PD samples to the overall concentration range of the routine sample data. This is accomplished through the application of critical values determined by the Kolmogorov-Smirnov test (Conover, 1980) which assesses the ability of the duplicate samples to track the distribution of routine sample concentrations.

Representativeness of the homogenization and subsampling procedures at the preparation and analytical laboratories is assessed using precision estimates for the PD and AD samples, respectively.

7.1.5 Assessment of Completeness

Sampling completeness is assessed by comparing the actual number of pedons and associated horizons sampled to that number specified in the MASS design. Completeness of the sample preparation and analysis is easily calculated using data from the verified data base, while completeness of the data from a data user's perspective is determined using confidence level 0, 1, and 2 data as a percentage of the entire validated data base (see Section 7.2).

7.1.6 Assessment of Comparability

Comparability is perhaps the most difficult of the data quality attributes to assess, primarily because of the many different aspects of comparison that are involved. Following completion of the MASS, a comparison is made across the Northeastern, SBRP, and Mid-Appalachian regions that focuses on method differences, audit sample results, laboratory effects, and other QA features of the surveys. Comparison of the DDRP data bases to other similar data bases may also be undertaken. Summary statistics are used to collate individual values into pooled groups that enable the data users to discern trends of interest among the surveys.

7.2 Overview of Validation Procedures

While the verification procedures evaluate data at the sample/batch level, validation procedures examine the plausibility of data in the context of a subregional set of samples. The MASS sampling strategy generally groups those soils having similar physical and chemical characteristics together. The validation process identifies unusual data that warrant special attention when used in statistical analysis, particularly in regional estimates concerning a target population of soils. Observations identified as anomalous during the review of routine data at the sampling class/horizon level or subregional level are considered outliers in relation to the remainder of the data. Outliers are identified using the Box and Whisker outlier test (Velleman and Hoaglin, 1981). The outliers may result from the natural variability of soils in the set of watersheds or from anthropogenic disturbances in the natural environment. Other sources may be derived from sampling, preparation, or analytical measurement uncertainty.

Although outliers may represent unusual data in comparison with other data, these values are not necessarily inaccurate in their representation of a watershed. The validation process is not designed as a stringent pass or fail test, but rather as a way to identify points having suspicious origins. All routine sample data are subjected to a set of rigorous validation checks by ERL-C and ORNL personnel that results in a series of flags being appended on all data not meeting the criteria (see

Appendix K). Each reviewed datum is assigned a level of confidence based upon the number and weight of the laboratory qualifiers and the verification/validation flags assigned to that datum. The levels of confidence range from 0 to 4, where Levels 3 and 4 data are suspected to be invalid for most uses. The data users generally consider Levels 0, 1, and 2 data to be suitable for most modeling applications.

The verified data are subjected to an investigation of parameter relationships within a sampling class/horizon group.

7.3 Quality Assurance Reports to Management

The QA staff is required to produce a series of reports, both verbal and written, to document the MASS QA activities, as described below.

7.3.1 Status Reporting

Communication among the various participants in the MASS is maintained through scheduled conference calls, electronic mail, site visits, and meetings. These activities provide all participants with the current status of operations and allow prompt discussion and resolution of issues related to the research plan, methodologies, or QA implementation.

Task leaders for the various stages of the MASS provide a written summary of operations to ERL-C on a quarterly basis. These reports describe the kinds of data collected as well as summarize the QA activities associated with the data. The summary of QA activities includes the following:

- Overview of QA activities
- List of changes to the QA program
- Results of system and performance audits
- Assessment of data quality based on the verified data bases
- Documentation of unfavorable incidents and corrective actions
- Distribution of updated control charts
- Results of special studies

Reports relating to data quality assessment are also prepared by QA staff. These reports include interpretation of performance audits and replicate sample data, estimates of measurement error, and identification of any major discrepancies found during the assessment. The reports are submitted to the technical monitor at EMSL-LV.

7.3.2 Formal Reporting

In addition to this QA Plan, the DDRP staff at EMSL-LV produces laboratory operations manuals for use in the preparation and analysis of soil samples. Upon completion of the data verification activities, summary QA reports of the sample preparation and sample analysis data are produced and distributed to all cooperating DDRP staff and data users.

Section 8

Data Management System

8.1 Overview of the Data Bases

The purpose of data base management for the MASS is to facilitate the collection, entry, review, modification, and distribution of all data associated with the survey (see Figure 8-1). Additional tasks include the data analysis for report generation, statistical analysis, verification, and data file security. The MASS final data base contains three progressive versions of the data gathered: (1) raw data base, (2) verified data base, and (3) validated data base. A user's guide has been developed to assist the data users in understanding the structure, codes, and flags of the DDRP data bases (Turner et al., 1989).

The raw data base is the version of data that is produced from the data entry operation. This data base is assembled by EMSL-LV and sent to ORNL for storage and control of the official raw data base. It is comprised of data from three sources: field sampling, sample preparation, and sample analysis. Each of these data sources contributes to the completed raw data base.

The verified data base has the same structure as the raw data base but is modified to reflect changes resulting from data verification activities. All modifications are tracked with an electronic audit trail system. The verified data base is generated by EMSL-LV and sent to ERL-C and ORNL for processing and validation.

The validated data base consists of a file listing all verification and validation flags plus a single level of confidence assigned for each datum, as well as transposed files in tabular format containing the higher quality data and imputed data replacing the lower quality data in an enhanced data set.

8.1.1 Field Sampling Data

The data collected during the field sampling operation are recorded on SCS-SOI-232 field data forms by the sampling crews. An initial review of each form is performed by the crew leader before copies are sent to the preparation laboratory manager and to the EMSL-LV QA staff, where the data are double entered into the NCC IBM with SAS screens. Entries are compared and reviewed for entry errors and the corrected data are added to the raw data base file. This file is archived and made available to the data base manager. The verification program is run on a working copy of the raw data base in order to perform extensive data checks and reviews. As data anomalies are resolved with each sampling crew and field liaison, corrections are entered into the working copy in order to create the verified data base. The program is run once more in order to assign verification flags and then is submitted to the data base manager.

The data structure for the field data bases consists of two files: the pedon base data and the pedon horizon data. The transfer of field data forms occurs simultaneously for both types of data, but the computer operations are performed separately.

8.1.2 Preparation Laboratory Data

The data generated at the preparation laboratory are entered directly into SAS files on a personal computer in the laboratory. Upon receipt of soil samples and field data forms, the sample receipt data are entered and checked. As analyses are performed in the laboratory, the data are also entered into the computer and verification programs are run to check the data. All raw and verified data files are transferred to the NCC IBM for

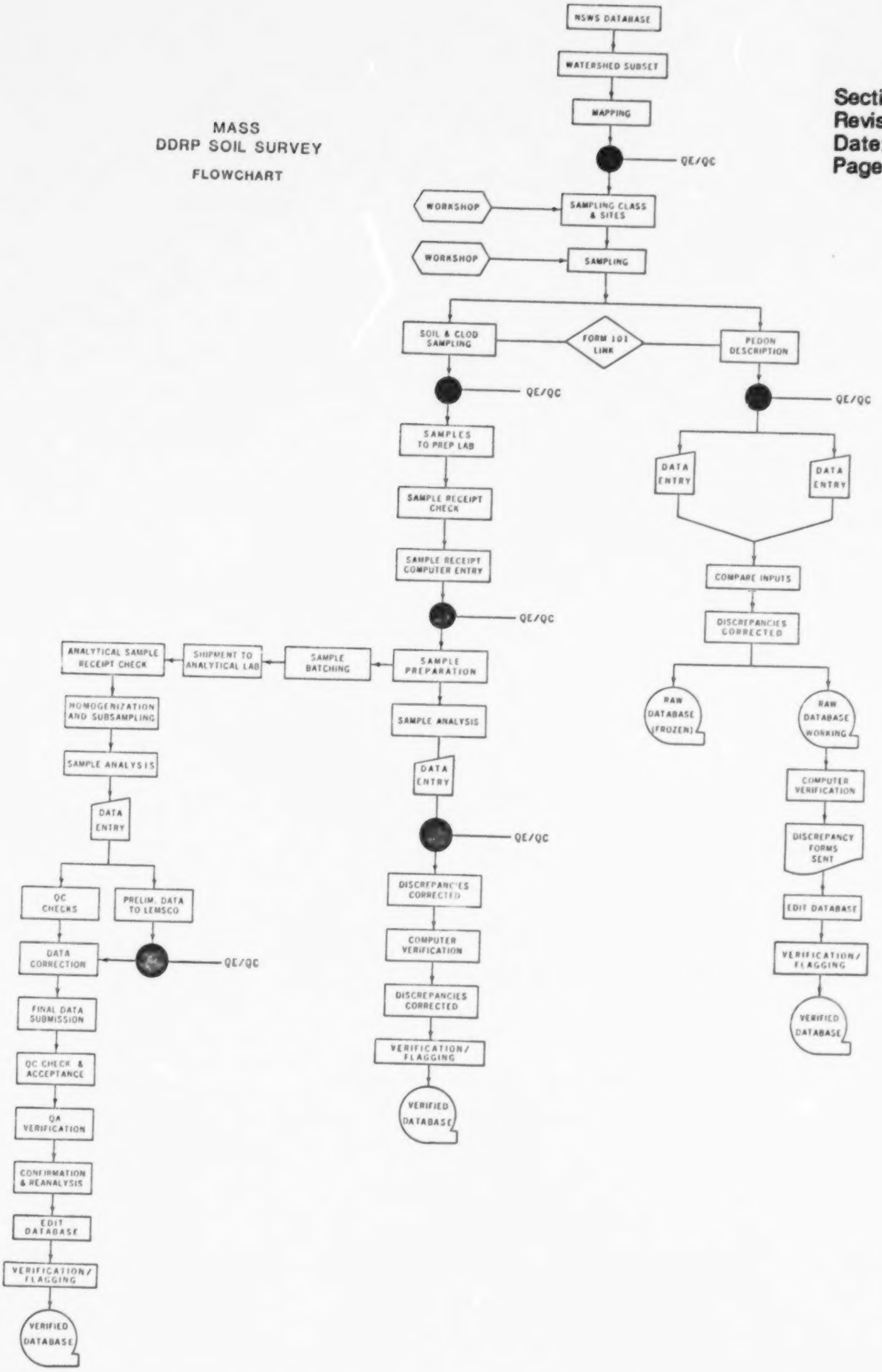

MASS
DDRP SOIL SURVEY
FLOWCHART
NSWS DATABASE
WATERSHED SUBSET
MAPPING
QE/QC
WORKSHOP
SAMPLING CLASS & SITES
WORKSHOP
SAMPLING
SOIL & CLOD SAMPLING
FORM 101 LINK
PEDON DESCRIPTION
QE/QC
QE/QC
SAMPLES TO PREP LAB
DATA ENTRY
DATA ENTRY
SAMPLE RECEIPT CHECK
SAMPLE RECEIPT COMPUTER ENTRY
COMPARE INPUTS
QE/QC
DISCREPANCIES CORRECTED
ANALYTICAL SAMPLE RECEIPT CHECK
SHIPMENT TO ANALYTICAL LAB
SAMPLE BATCHING
SAMPLE PREPARATION
RAW DATABASE (FROZEN)
RAW DATABASE WORKING
HOMOGENIZATION AND SUBSAMPLING
SAMPLE ANALYSIS
SAMPLE ANALYSIS
DATA ENTRY
COMPUTER VERIFICATION
DATA ENTRY
DISCREPANCY FORMS SENT
QE/QC
QC CHECKS
PRELIM. DATA TO LEMSCO
DISCREPANCIES CORRECTED
EDIT DATABASE
DATA CORRECTION
QE/QC
COMPUTER VERIFICATION
VERIFICATION/ FLAGGING
FINAL DATA SUBMISSION
DISCREPANCIES CORRECTED
VERIFIED DATABASE
VERIFICATION/ FLAGGING
QC CHECK & ACCEPTANCE
VERIFIED DATABASE
QA VERIFICATION
CONFIRMATION & REANALYSIS
EDIT DATABASE
VERIFICATION/ FLAGGING
VERIFIED DATABASE

Figure 8-1. Flowchart of data management activities for the Direct/Delayed Response Project.

storage and eventual integration with other MASS data and undergo further verification, e.g., comparison of field-moist pH values with air-dry pH values from the analytical laboratories. Finally, the preparation laboratory data are merged with the analytical laboratory data to form the laboratory data base.

The raw data file for the preparation laboratory data on the NCC IBM consists of only one file containing all of the required data. Five intermediate files on the personal computer are used to capture the laboratory operations data and sample tracking information.

8.1.3 Analytical Laboratory Data

Data generated at the analytical laboratory are entered by laboratory personnel into the Laboratory Entry and Verification Information System (LEVIS) on personal computers at each laboratory. The LEVIS scheme facilitates the entry, edit, and review of intermediate data, as well as the calculation of final data values. The LEVIS program also performs QE/QC checks and produces summary reports.

Phone modem access to each laboratory personal computer is available to facilitate the transfer of preliminary data. Preliminary data are used only by the QA staff to evaluate the current status of laboratory operations and data entry. The laboratories deliver the official analytical data to EMSL-LV on floppy disks in the LEVIS data base structure. The QA staff performs additional QE/QC and verification checks on the personal computer and the data are reviewed for confirmation/reanalysis requirements. The entry of data from reanalysis follows the same procedures identified above.

The LEVIS data entry screens are designed to prompt an entry field for each parameter separately and to combine the parameters into groups for storage. The intermediate personal computer data file structure consists of 42 files and can be grouped into three main data types of 14 files each: routine data, matrix spike data, and QCCS data. The raw data files submitted by the laboratories and the personal computer verified data files are uploaded to the NCC IBM to create the EMSL-LV raw data base and verified data base. Additional verification programs on the NCC IBM are run to complete the verification process.

8.2 Data Base Audits

All of the DDRP data bases are subject to independent audits by a group of reviewers under the direction of EPA through the technical director. The purpose of the audits is to ensure that all aspects of the data tracking and management system are being conducted properly. The audits are performed in a manner similar to those in the National Surface Water Survey conducted by an independent auditor contracted by the EPA (IS&T, 1986).

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Appendix A

SCS-SOI-232 Field Data Form and Codes

Field data describing each sampled pedon are recorded on the SCS-SOI-232 form. This appendix also includes a list of the specific codes to be used on the form.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL DESCRIPTION

SCS-SOI-232
3-87

SOIL SERIES REPRESENTED	DATE MO DAY YR	SITE ID ST COUNTY UNIT	SUB	MLRA	LATITUDE DEG MIN SEC DIR	LONGITUDE DEG MIN SEC DIR

[redacted]

SHP SLP ASP A M R DEG	[redacted]	PHYS MAJ LOC	PEDON CLASSIFICATION O SO GG SG PSC MN RX TMP OTH

PRECIP	WATERTABLE DEPTH DAYS KD					ELEVATION	PARENT MATERIAL 1 W B M ORIG 2 W B M ORIG 3 W B M ORIG 4 W B M ORIG BDRK

TEMPERATURE AVERAGE AIR ANN SUM WINTER AVERAGE SOIL ANN SUM WINTER	MST REG	WEATHER STATION NO	CONTROL SECTION PSC		

DIAGNOSTIC FEATURES DEPTH KND DEPTH KND DEPTH KND DEPTH KND DEPTH KND					FLOODING FRQ [redacted]	PONDING FRQ [redacted]

VEGETATION SPECIES

1	2	3	4	5
6	7	8	9	10

[redacted]

DESCRIBERS NAMES

LOCATION DESCRIPTION

NOTES

WATERSHED	CLASS		TRANSECT DIR	SEW	WATERSHED NAME

	DEPTH	HORIZON DESIGNATION			THICKNESS	DRY COLOR					MOIST COLOR					TEXTURE	
	UPPER / LOWER	DISC	MASTER LETTER	SUFFIX	AVE(a) / MAX(b) / MIN(c)	LOC	%	HUE	VAL	CHR	LOC	%	HUE	VAL	CHR	CLASS	MOD
1					a												
					b												
					c												
2					a												
					b												
					c												
3					a												
					b												
					c												
4					a												
					b												
					c												
5					a												
					b												
					c												
6					a												
					b												
					c												
7					a												
					b												
					c												
8					a												
					b												
					c												
9					a												
					b												
					c												
10					a												
					b												
					c												

FREE FORM NOTES

	SAMPLE NUMBERS	BULK DENSITY		HORIZON NOTES
		NO	TYP	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

STRUCTURE			CONSISTENCE			MOTTLES						SURFACE FEATURES									
GRD	SZ	SHP	a) DRY b) MOIST c) OTHER	a) ST b) PL	CEM	AB	SZ	CON	HUE	VAL	CHR	KND	AB	CN	DST	LOC	HUE	VAL	CHR	BOUNDARY	
			a	a																	1
			b	b																	
			c																		
			a	a																	2
			b	b																	
			c																		
			a	a																	3
			b	b																	
			c																		
			a	a																	4
			b	b																	
			c																		
			a	a																	5
			b	b																	
			c																		
			a	a																	6
			b	b																	
			c																		
			a	a																	7
			b	b																	
			c																		
			a	a																	8
			b	b																	
			c																		
			a	a																	9
			b	b																	
			c																		
			a	a																	10
			b	b																	
			c																		

FREE FORM NOTES

EFFERVESCENCE			FIELD MEASURED PROPERTIES		FIELD MEASURED PROPERTIES		WETNESS	HYDO COND	ROOTS			PORES				CONCENTRATIONS				ROCK FRAGMENTS				ROCK FRAGMENTS			
CL	AG	EX	KND	AMOUNT	KND	AMOUNT			QT	SZ	LOC	SHP	QT	SZ	CN	KND	QT	SHP	SZ	KND	%	RND	SZ	KND	%	RND	SZ
			P																								
			C L																								
			P																								
			C L																								
			P																								
			C L																								
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			C L																								
			P																								
			C L																								

FREE FORM NOTES

LOG	
WEATHER	
SET I.D.	
UNDERSTORY VEG.	
SLIDES #s PED FACE	OVERSTORY
UNDERSTORY	LANDSCAPE

SITE CODES

Slope Shape (U/A)

1	convex
2	plane
3	concave
4	undulating
5	complex

Geomorphic Component (GM)

1	interfluve
2	head slope
3	side slope
4	nose slope

Hillslope Component (HS)

1	summit
2	shoulder
3	back slope
4	foot slope
5	toe slope

Slope Aspect (ASP)

45	northeast
90	east
135	southeast
180	south
225	southwest
270	west
315	northwest
0	north

Major Landform (MAJ)

BA	Badlands
BI	Barrier Island
BO	Bolson
CA	Canyon
CF	Coalescent Fan Piedmont
CP	Coastal Plain
DF	Drumlin Field
DP	Deeply Disected Plateau
FH	Foothills
GF	Glaciofluvial Landform
GU	Glaciated Upland
HH	High Hills
HI	Hills
KP	Karst Plain
LP	Lake Plain
LU	Level or Undulating Upland
LV	Lava Plain
MO	Mountains
MV	Mountain Valley
PI	Piedmonts
PL	Plains
PT	Plateau
RV	River Valley
SB	Semibolson
SH	Sandhills
TA	Tableland
VM	Volcanic Mountains

Local Landform (LOC)

AF	Alluvial Fan
AP	Alluvial Flat (plain)
BE	Beach
BF	Barrier Flat
BO	Bog
BS	Backswamp
BT	Beach Terrace
BU	Butte
CB	Carolina Bay
CO	Cove
CR	Crater
CU	Cuesta
DE	Delta
DO	Dome
DR	Drumlin
DU	Dune
EK	Esker
EM	End Moraine
ES	Escarpment
FE	Felsenmeer
FP	Flood Plain
FT	Fluvial Terrace
FJ	Fjord
GM	Ground Moraine
HO	Hogback
HS	Hillside
KA	Kame
KE	Kettle
LS	Low Sand Ridge
LT	Lake Terrace
MA	Marsh
ME	Mesa
MO	Mountainside
MT	Marine Terrace
OP	Outwash Plain
OT	Outwash Terrace
OX	Oxbow
PE	Pediment
PL	Playa
RI	Ridge
SB	Structural Bench
SI	Sink
SL	Slough
SM	Salt Marsh
SW	Swamp
VC	Volcanic Cone
VS	Valleyside

Kind of Watertable (KD)

0	none
2	perched
3	apparent
4	ground

Land Use (LU)

A	abandonded cropland
C	cropland
E	forest land grazed
F	forest land not grazed
G	pasture land and native pasture
H	horticultural land
I	cropland irrigated
J	hayland
L	waste disposal land
N	barren land
O	other
P	rangeland grazed
Q	wetlands drained
R	wetlands
S	rangeland not grazed
T	tundra
U	urban and built-up land

Stoniness Class (ST)

0	class 0
1	class 1
2	class 2
3	class 3
4	class 4
5	class 5

Hydraulic Conductivity Class (HC)

1	very slow
2	slow
3	moderately slow
4	moderate
5	moderately rapid
6	rapid
7	very rapid

Drainage Class (DR)

1	very poorly drained
2	poorly drained
3	somewhat poorly drained
4	moderately well drained
5	well drained
6	somewhat excessively drained
7	excessively drained

Parent Material Weathering (W)

1	slight
2	moderate
3	strong

Bedrock Inclination (B)

1	< 5 degree inclination
2	5-30 degree inclination
3	> 30 degree inclination

Parent Material Mode of Deposition (M)

A	alluvium
D	glacial drift
E	eolian
F	mine spoil and earth fill
G	glacial outwash
H	volcanic ash
I	lacustrine sands
J	lacustrine silts
K	lacustrine clays
L	lacustrine
M	marine
N	marine sands
O	organic
P	marine silts
Q	marine clays
R	solid rock
S	eolian-sand
T	glacial till
U	unconsolidated sediments
V	local colluvium
W	loess
X	residuum
Y	solifluctate
Z	estuarine

Parent Material Origin (ORIG)

A0	sandstone unspecified
A1	sandstone-noncalcareous
A2	arkosic-sandstone
A4	sandstone-calcareous
B0	interbedded sedimentary unspecified
B1	limestone-sandstone-shale
B2	limestone-sandstone
B3	limestone-shale
B4	limestone-siltstone
B5	sandstone-shale
B6	sandstone-siltstone
B7	shale-siltstone
C0	conglomerate unspecified
C1	conglomerate-noncalcareous
C2	conglomerate-calcareous
E0	ejecta-ash unspecified
E1	acidic-ash
E2	basic-ash
E3	basaltic-ash
E4	andesitic-ash
E5	cinders
E6	pumice
E7	scoria
E8	volcanic bombs
H0	shale unspecified
H1	shale-noncalcareous
H2	shale-calcareous
H3	shale-clay
I0	igneous unspecified
I1	igneous-coarse (or intrusive)
I2	igneous-basic (eg., gabbro)
I3	igneous-intermediate (eg., diorite)
I4	igneous-granite
I5	igneous-fine (or extrusive)
I6	igneous-basalt
I7	igneous-andesite
I8	igneous-acid (eg., rhyolite)

Parent Material Origin (cont.)

I9	igneous-ultrabasic
K0	organic unspecified
K1	mossy material
K2	herbaceous material
K3	woody material unspecified
K4	wood fragments
K5	logs and stumps
K6	charcoal
K7	coal
L0	limestone unspecified
L1	chalk
L2	marble
L3	dolomite
L4	limestone-phosphatic
L5	limestone-arenaceous
L6	limestone-argillaceous
L7	limestone-cherty
M0	metamorphic unspecified
M1	gneiss unspecified
M2	gneiss-acidic
M3	gneiss-basic
M4	serpentine
M5	schist unspecified
M6	schist-acidic
M7	schist-basic
M8	slate
M9	quartzite
P0	pyroclastic unspecified
P1	tuff unspecified
P2	tuff-acidic
P3	tuff-basic
P4	volcanic breccia unspecified
P5	breccia-acidic
P6	breccia-basic
P7	tuff-breccia
P8	aa
P9	pahoehoe
S0	sedimentary unspecified
S1	marl
S2	glauconite
T0	siltstone unspecified
T1	siltstone-noncalcareous
T2	siltstone-calcareous
Y0	mixed unspecifed
Y1	mixed-noncalcareous
Y2	mixed-calcareous
Y4	mixed-igneous-metamorphic & sed.
Y5	mixed-igneous & metamorphic
Y6	mixed-igneous & sedimentary
Y7	mixed-metamorphic & sedimentary
MS	meta-sedimentary

Bedrock fracture (BDRK)

1	< 10 cm between fractures
2	10 to 45 cm between fractures
3	45 cm to 1.0 m between fractures
4	1.0 to 2.0 m between fractures
5	> 2.0 m between fractures

Moisture Regime (MST RGE)

AQ	aquic
AR	aridic
PA	peraquic
PU	perudic
TO	torric
UD	udic
US	ustic
XE	xeric

Erosion Class (ER WA)

0	none
1	slight
2	moderate
3	severe

Runoff Class (RN OF)

1	none
2	ponded
3	very slow
4	slow
5	rapid
6	moderate
7	very rapid

Diagnostic Features (KND)

A	anthropic
B	cambic
C	calcic
D	durinodes
E	petrocalcic
F	fragipan
G	gypsic
H	histic
I	sombric
J	petrogypsic
K	placic
L	lithic contact
M	mollic
N	natric
O	ochric
P	plaggen
Q	albic
R	argic
S	spodic
T	argillic
U	umbric
V	sulfuric
W	paralithic contact
X	oxic
Y	salic
Z	duripan
1	kandic

Flooding and Ponding, frequency

NO	none
RA	rare
OC	occasional
FR	frequent
CO	common

HORIZON CODES

Color location (LOC)

0	not given
1	interior
2	exterior
3	crushed
4	dithionite-citrate pretreated
5	after exposure to air
6	after ignition
7	pyrophosphate extract

Texture class (CLASS)

C	clay
CE	coprogenous earth
CIND	cinders
CL	clay loam
COS	coarse sand
COSL	coarse sandy loam
CSCL	coarse sandy clay loam
DE	diatomaceous earth
FB	fibric material
FM	fragmental material
FS	fine sand
FSL	fine sandy loam
G	gravel
GYP	gypsiferous earth
ICE	ice or frozen soil
L	loam
LCOS	loamy coarse sand
LFS	loamy fine sand
LS	loamy sand
LVFS	loamy very fine sand
MARL	marl
MPT	mucky peat
MUCK	muck
OPWD	oxide protected weathered bedrock
PDOM	partially decomposed organics
PEAT	peat
S	sand
SC	sandy clay
SCL	sandy clay loam
SG	sand and gravel
SI	silt
SIC	silty clay
SICL	silty clay loam
SIL	silt loam
SL	sandy loam
SP	sapric material
U	unkown texture
UDOM	undecomposed organics
UWB	unweathered bedrock
VAR	variable
VFS	very fine sand
VFSL	very fine sandy loam
WB	weathered bedrock

Texture modifier (MOD)

BY	bouldery
BYV	very bouldery
BYX	extremely bouldery
CB	cobbly
CBA	angular cobbly
CBV	very cobbly
CBX	extremely cobbly
CN	channery
CNV	very channery
CNX	extremely channery
FL	flaggy
FLV	very flaggy
FLX	extremely flaggy
GR	gravelly
GRC	coarse gravelly
GRF	fine gravelly
GRV	very gravelly
GRX	extremely gravelly
ST	stony
STV	very stony
STX	xtremely stony

Structure grade (GRD)

0	structureless
1	weak
2	moderate
3	strong
4	very strong
5	weak and moderate
6	moderate and strong

Structure size (SZ)

CO	coarse
CV	coarse and very coarse
F	fine
FF	very fine and fine
FM	fine and medium
M	medium
MC	medium and coarse
TK	thick
TN	thin
VC	very coarse
VF	very fine
VK	very thick
VN	very thin

Structure shape (SHP)

ABK	angular blocky
BK	blocky
CDY	cloddy
COL	columnar
CR	crumb
GR	granular
LP	lenticular
MA	massive
PL	platy
PR	prismatic
SBK	subangular blocky
SGR	single grain
WEG	wedge

Dry consistence (DRY)

EH	extremely hard
H	hard
L	loose
S	soft
SH	slightly hard
VH	very hard

Moist consistence (MOIST)

EFI	extremely firm
FI	firm
FR	friable
L	loose
VFI	very firm
VFR	very friable

Other consistence (OTHER)

B	brittle
CO	uncememented
D	deformable
I	indurated
MS	moderately smeary
R	rigid
SC	strongly cemented
SD	semi deformable
SM	smeary
VR	very rigid
VWC	very weakly cemented
WC	weakly cemented
WSM	weakly smeary

Stickiness (ST)

S	sticky
SO	non sticky
SS	slightly sticky
VS	very sticky

Plasticity (PL)

P	plastic
PO	non plastic
SP	slightly plastic
VP	very plastic

Cementing agent (CEM)

H	humus
I	iron
L	lime
S	silica
X	lime and silica

Mottle abundance (AB)

F	few
C	common
M	many

Mottle size (SZ)

1	fine
12	fine and medium
13	medium and coarse
2	medium
3	coarse

Mottle distinctness

D	distinct
F	faint
P	prominent

Surface features kind of coat (KND)

A	skeletans over cutans
B	black stains
C	chalcedony on opal
D	clay bridging
G	gibbsite coats
I	iron stains
K	intersecting slickensides
L	lime or carbonate coats
M	manganese or iron-manganese stains
O	organic coats
P	pressure faces
Q	nonintersecting slickensides
S	skeletans (sand or silt)
T	clay films (cutans)
U	coats
X	oxide coats

Abundance of coats (AB)

F	few
C	common
M	many

Continuity of coat (CN)

C	continuous
D	discontinuous
P	patchy

Distinctness of coat (DST)

D	distinct
F	faint
P	prominent

Location of coat (LOC)

B	between sand grains
C	on tops of columns
F	on faces of peds and in pores
H	on horizontal faces of peds
I	in root channels and/or pores
L	on lower surfaces of peds or stones
M	on bottoms of plates
N	on nodules
P	on faces of peds
R	on rock fragments
S	on sand and gravel
T	throughout
U	on upper surfaces of peds or stones
V	on vertical faces of peds
Z	on vert. and hor. faces of peds

Boundary distinctness

A	abrupt
C	clear
D	diffuse
G	gradual

Boundary topography

B	broken
I	irregular
S	smooth
W	wavy

Effervescence class (CL)

0	very slightly effervescent
1	slightly effervescent
2	strongly effervescent
3	violently effervescent

Effervescence agent (AG)

H	HCl, unspecified
I	HCl, 1 normal
O	Hydrogen peroxide, 3 to 4 percent
P	Hydrogen peroxide, unspecified

Effercescence extension (EX)

C	continuous
D	discontinuous

Kind of field measurement (KND)

CL	clay
PB	Bromthymol blue
PC	Cresol red
PG	Bromcresol green
PH	hellige-truog
PL	LaMotte-Morgan
PP	Phenol red
PR	Chlorophenol red
PS	soiltest
PT	Thymol-blue
PY	pH Ydrion
SA	sand
SC	coarse and very coarse sand
SF	fine sand
SI	silt
SM	medium sand
SV	very fine sand
OB	fiber unrubbed
OR	rubbed fiber

Wetness class (WETNESS)

D	dry
M	moist
W	wet

Hydraulic conductivity class

1	Very slow
2	slow
3	Moderately slow
4	Moderate
5	Moderately rapid
6	Rapid
7	Very rapid

Root quantity (QT)

VF	very few
FF	very few to few
F	few
FC	few to common
C	common
CM	common to many
M	many

Root size (SZ)

1	fine 1-2mm
11	very fine and fine
12	fine and medium
13	fine to coarse
2	medium 2-5mm
23	medium and coarse
3	coarse > 5mm
V1	very fine < 1mm

Root location (LOC)

C	in cracks
M	in mat at top of horizon
P	between peds
S	matted around stones
T	throughout

Shape of pore (SHP)

IE	filled with coarse material
IF	void between rock fragments
IR	interstitial
IT	interstitial and tubular
TC	continuous tubular
TD	discontinuous tubular
TE	dendritic tubular
TS	constricted tubular
TU	tubular
VS	vesicular
VT	vesicular and tubular

Quantity of pores (QT)

VF	very few
FF	very few to few
F	few
FC	few to common
C	common
CM	common to many
M	many

Size of pore (SZ)

1	fine .05-2mm
11	very fine and fine
12	fine and medium
13	fine to coarse
2	medium 2-5mm
23	medium and coarse
3	coarse > 5mm
V1	very fine < .05mm

Pore Continuity (CN)

L	Low
M	Moderate
H	High

Kind of concentration (KND)

A2	clay bodies
B1	barite crystals
B2	soft masses of barite
C1	calcite crystals
C2	soft masses of lime
C3	lime concretions
C4	lime nodules
D1	mica flakes
D2	soft dark masses
D3	dark concretions
D4	dark nodules
E3	gibbsite concretions
E4	gibbsite nodules
F1	plinthite segregations
F2	soft masses of iron
F3	iron concretions
F4	ironstone nodules
G1	gypsum crystals
G2	masses of gypsum
G3	nests of gypsum
G4	gypsum threads
H1	halite crystals
H2	salt masses
K2	soft masses of carbonate
K3	carbonate concretions
K4	carbonate nodules
K5	carbonate threads
M1	nonmagnetic shot
M2	soft masses of iron-manganese
M3	iron-manganese concretions
M4	magnetic shot
S1	opal crystals
S2	soft masses of silica
S3	silica concretions
S4	durinodes
T2	worm casts
T3	insects casts
T4	worm nodules

Quantity of concentrations (QT)

VF	very few
FF	very few to few
F	few
FC	few to common
C	common
CM	common to many
M	many

Shape of concentration (SHP)

C	cylindrical
D	dendritic
O	rounded
P	plate like
T	threads
Z	irregular

Size of concentration (SZ)

1	fine <2mm
12	fine and medium
2	medium 2-5mm
23	medium and coarse
3	coarse > 5-20mm
34	coarse and very coarse
4	very coarse 20-76mm
45	very coarse and extremely coarse
5	extremely coarse > 76mm

Roundness of rock fragment (RND)

1	angular
2	subangular
3	subrounded
4	rounded
5	well rounded

Size of rock fragment (SZ)

1	pebbles
2	cobbles
3	stones
4	boulders
5	channers
6	flagstones

Kind of rock fragment (KND)

A	sandstone
B	mixed sedimentary
E	ejecta
F	ironstone
H	shale
I	igneous rocks
K	organic fragments
L	limestone
M	metamorphic rocks
O	oxide-protected rock
P	pyroclastic rocks
R	saprolite
S	sedimentary rocks
Y	mixed lithology

CLASSIFICATION

Classification, Great Group

Alfisols

AAQAL	Albaqualf
AAQDU	Duraqualf
AAQFR	Fragiaqualf
AAQGL	Glossaqualf
AAQKA	Kandiaqualf
AAQNA	Natraqualf
AAQOC	Ochraqualf
AAQPN	Plinthaqualf
AAQUM	Umbraqualf
ABOCR	Cryoboralf
ABOEU	Eutroboralf
ABOFR	Fragiboralf
ABOGL	Glossoboralf
ABONA	Natriboralf
ABOPA	Paleboralf
AUDAG	Agrudalf
AUDFE	Ferrudalf
AUDFR	Fragiudalf
AUDFS	Fraglossudalf
AUDGL	Glossudalf
AUDHA	Hapludalf
AUDKA	Kandiudalf
AUDKH	Kandhapludalf
AUDNA	Natrudalf
AUDPA	Paleudalf
AUDRH	Rhodudalf
AUSDU	Durustalf
AUSHA	Haplustalf
AUSKA	Kandiustalf
AUSKH	Kandhaplustalf
AUSNA	Natrustalf
AUSPA	Paleustalf
AUSPN	Plinthustalf
AUSRH	Rhodustalf
AXEDU	Durixeralf
AXEFR	Fragixeralf
AXEHA	Haploxeralf
AXENA	Natrixeralf
AXEPA	Palexeralf
AXEPN	Plinthoxeralf
AXERH	Rhodoxeralf

Aridisols

DARDU	Durargid
DARHA	Haplargid
DARND	Nadurargid
DARNT	Natrargid
DARPA	Paleargid
DORCL	Calciorthid
DORCM	Camborthid
DORDU	Durorthid
DORGY	Gypsiorthid
DORPA	Paleorthid
DORSA	Salorthid

Entisols

EAQCR	Cryaquent
EAQFL	Fluvaquent
EAQHA	Haplaquent
EAQHY	Hydraquent
EAQPS	Psammaquent
EAQSU	Sulfaquent
EAQTR	Tropaquent
EARAR	Arent
EFLCR	Cryofluvent
EFLTO	Torrifluvent
EFLTR	Tropofluvent
EFLUD	Udifluvent
EFLUS	Ustifluvent
EFLXE	Xerofluvent
EORCR	Cryorthent
EORTO	Torriorthent
EORTR	Troporthent
EORUD	Udorthent
EORUS	Ustorthent
EORXE	Xerorthent
EPSCR	Cryopsamment
EPSQU	Quartzipsamment
EPSTO	Torripsamment
EPSTR	Tropopsamment
EPSUD	Udipsamment
EPSUS	Ustipsamment
EPSXE	Xeropsamment

Histosols

HFIBO	Borofibrist
HFICR	Cryofibrist
HFILU	Luvifibrist
HFIME	Medifibrist
HFISP	Sphagnofibrist
HFITR	Tropofibrist
HFOBO	Borofolist
HFOCR	Cryofolist
HFOTR	Tropofolist
HHEBO	Borohemist
HHECR	Cryohemist
HHELU	Luvihemist
HHEME	Medihemist
HHESI	Sulfihemist
HHESO	Sulfohemist
HHETR	Tropohemist
HSABO	Borosaprist
HSACR	Cryosaprist
HSAME	Medisaprist
HSATR	Troposaprist

Inceptisols

IANCR	Cryandept
IANDU	Durandept
IANDY	Dystrandept
IANEU	Eutrandept
IANHY	Hydrandept
IANPK	Placandept
IANVI	Vitrandept
IAQAN	Andaquept
IAQCR	Cryaquept
IAQFR	Fragiaquept
IAQHL	Halaquept
IAQHP	Haplaquept
IAQHU	Humaquept
IAQPK	Placaquept
IAQPN	Plinthaquept
IAQSU	Sulfaquept
IAQTR	Tropaquept
IOCCR	Cryochrept
IOCDU	Durochrept
IOCDY	Dystrochrept
IOCEU	Eutrochrept
IOCFR	Fragiochrept
IOCUS	Ustochrept
IOCXE	Xerochrept
IPLPL	Plaggept
ITRDY	Dystropept
ITREU	Eutropept
ITRHU	Humitropept
ITRSO	Sombritropept
ITRUS	Ustropept
IUMCR	Cryumbrept
IUMFR	Fragiumbrept
IUMHA	Haplumbrept
IUMXE	Xerumbrept

Mollisols

MALAR	Argialboll
MALNA	Natralboll
MAQAR	Argiaquoll
MAQCA	Calciaquoll
MAQCR	Cryaquoll
MAQDU	Duraquoll
MAQHA	Haplaquoll
MAQNA	Natraquoll
MBOAR	Argiboroll
MBOCA	Calciboroll
MBOCR	Cryoboroll
MBOHA	Haploboroll
MBONA	Natriboroll
MBOPA	Paleboroll
MBOVE	Vermiboroll
MRERE	Rendoll
MUDAR	Argiudoll
MUDHA	Hapludoll
MUDPA	Paleudoll
MUDVE	Vermudoll
MUSAR	Argiustoll
MUSCA	Calciustoll
MUSDU	Durustoll
MUSHA	Haplustoll
MUSNA	Natrustoll
MUSPA	Paleustoll

Mollisols (cont)

MUSVE	Vermustoll
MXEAR	Argixeroll
MXECA	Calcixeroll
MXEDU	Durixeroll
MXEHA	Haploxeroll
MXENA	Natrixeroll
MXEPA	Palexeroll

Oxisols

OAQAC	Acraquox
OAQEU	Eutraquox
OAQHA	Haplaquox
OAQPN	Plinthaquox
OPRAC	Acroperox
OPREU	Eutroperox
OPRHA	Haploperox
OPRKA	Kandiperox
OPRSO	Sombriperox
OTOAC	Acritorrox
OTOEU	Eutrotorrox
OTOHA	Haplotorrox
OUDAC	Acrudox
OUDEU	Eutrudox
OUDHA	Hapludox
OUDKA	Kandiudox
OUDSO	Sombriudox
OUSAC	Acrustox
OUSEU	Eutrustox
OUSHA	Haplustox
OUDKA	Kandiustox
OUSSO	Sombriustox

Spodosols

SAQCR	Cryaquod
SAQDU	Duraquod
SAQFR	Fragiaquod
SAQHA	Haplaquod
SAQPK	Placaquod
SAQSI	Sideraquod
SAQTR	Tropaquod
SFEFE	Ferrod
SHUCR	Cryohumod
SHUFR	Fragihumod
SHUHA	Haplohumod
SHUPK	Placohumod
SHUTR	Tropohumod
SORCR	Cryorthod
SORFR	Fragiorthod
SORHA	Haplorthod
SORPK	Placorthod
SORTR	Troporthod

Ultisols

UAQAL	Albaquult
UAQFR	Fragiaquult
UAQKA	Kandiaquult
UAQKH	Kandhaplaquult
UAQOC	Ochraquult
UAQPA	Paleaquult
UAQPN	Plinthaquult
UAQUM	Umbraquult
UHUHA	Haplohumult
UHUKA	Kandihumult
UHUKH	Kandhaplohumult
UHUPN	Plinthohumult
UHUSO	Sombrihumult
UUDFR	Fragiudult
UUDHA	Hapludult
UUDKA	Kandiudult
UUDKH	Kandhapludult
UUDPA	Paleudult
UUDPN	Plinthudult
UUDRH	Rhodudult
UUSHA	Haplustult
UUSKA	Kandiustult
UUSKH	Kandhaplustult
UUSPA	Paleustult
UUSPN	Plinthustult
UUSRH	Rhodustult
UXEHA	Haploxerult
UXEPA	Palexerult

Vertisols

VTOTO	Torrert
VUDCH	Chromudert
VUDPE	Pelludert
VUSCH	Chromustert
VUSPE	Pellustert
VXECH	Chromxerert
VXEPE	Pelloxerert

Classification, Subgroup

AA	Typic
AB	Abruptic
AB04	Abruptic aridic
AB08	Abruptic cryic
AB10	Abruptic haplic
AB14	Abruptic udic
AB16	Abruptic xerollic
AC	Acric
AC05	Acric Plinthic
AE	Aeric
AE03	Aeric arenic
AE05	Aeric grossarenic
AE06	Aeric humic
AE08	Aeric mollic
AE09	Aeric tropic
AE10	Aeric umbric
AL	Albaquic
AL02	Albaquultic
AL04	Albic
AL08	Albic glossic
AL10	Alfic
AL12	Alfic arenic
AL13	Alfic andeptic
AL16	Alfic lithic
AN	Andic
AN01	Andeptic
AN03	Andaquic
AN06	Andic dystric
AN08	Andic epiaquic
AN11	Andeptic glossoboric
AN20	Andic udic
AN22	Andic ustic
AN24	Andaqueptic
AN25	Anionic
AN30	Anthropic
AQ	Aqualfic
AQ02	Aquentic
AQ04	Aqueptic
AQ06	Aquic
AQ07	Aquic anionic
AQ08	Aquic arenic
AQ14	Aquic duric
AQ16	Aquic duriorthidic
AQ18	Aquic dystric
AQ24	Aquic haplic
AQ26	Aquic lithic
AQ28	Aquic petroferric
AQ34	Aquollic
AQ36	Aquultic
AR	Arenic
AR02	Arenic aridic
AR04	Arenic plinthaquic
AR06	Arenic plinthic
AR08	Arenic rhodic
AR10	Arenic ultic
AR14	Arenic umbric
AR16	Arenic ustalfic
AR18	Arenic ustollic
AR22	Argiaquic
AR24	Argiaquic xeric
AR26	Argic
AR28	Argic lithic
AR30	Argic pachic
AR32	Argic vertic
AR34	Aridic
AR36	Aridic calcic
AR42	Aridic duric
AR52	Aridic petrocalcic
BO	Boralfic
BO02	Boralfic lithic
BO04	Boralfic udic
BO06	Borollic
BO08	Borollic glossic
BO10	Borollic lithic
BO12	Borollic vertic

Classification, Subgroup (cont)

CA	Calcic
CA04	Calcic pachic
CA06	Calciorthidic
CA10	Calcixerollic
CA20	Cambic
CH	Chromic
CR	Cryic
CR10	Cryic lithic
CR14	Cyric pachic
CU	Cumulic
CU02	Cumulic udic
CU04	Cumulic ultic
DU	Durargidic
DU02	Duric
DU08	Durixerollic
DU10	Durixerollic lithic
DU12	Durorthidic
DU14	Durorthidic xeric
DY02	Dystric
DY03	Dystric entic
DY04	Dystric fluventic
DY06	Dystric lithic
EN	Entic
EN02	Entic lithic
EN06	Entic ultic
EP	Epiaquic
EU	Eutric
EU02	Eutrochreptic
EU04	Eutropeptic
FE	Ferrudalfic
FI	Fibric
FI02	Fibric terric
FL02	Fluvaquentic
FL06	Fluventic
FL12	Fluventic umbric
FR10	Fragiaquic
FR18	Fragic
GL02	Glossaquic
GL04	Glossic
GL10	Glossic udic
GL12	Glossic ustollic
GL16	Glossoboric
GR	Grossarenic
GR01	Grossarenic entic
GR04	Grossarenic plinthic
GY	Gypsic
HA	Haplaquodic
HA02	Haplic
HA07	Haploxerollic
HA09	Hapludic
HA12	Hapludollic
HA16	Haplustollic
HE	Hemic
HE02	Hemic terric
HI	Histic
HI02	Histic lithic
HI06	Histic pergelic
HU	Humic
HU02	Humic lithic
HU05	Humic pergelic
HU10	Humaqueptic
HU15	Humic rhodic
HU20	Humic xanthic
HY	Hydric
HY02	Hydric lithic
IN	Inceptic
KA	Kandic
KA02	Kandiudalfic
KA04	Kandiustalfic
KH	Kandhaplic
LE	Leptic
LI	Limnic
LI02	Lithic
LI04	Lithic mollic
LI05	Lithic pergelic
LI03	Lithic petrocalci
LI06	Lithic ruptic-alfic
LI07	Lithic ruptic-argic
LI08	Lithic ruptic-entic-xerollic
LI09	Lithic ruptic-entic
LI11	Lithic ruptic-xerorthentic
LI12	Lithic ultic
LI13	Lithic ruptic-ultic
LI14	Lithic umbric
LI15	Lithic ruptic-xerochreptic
LI16	Lithic ustic
LI18	Lithic ustollic
LI22	Lithic xeric
LI24	Lithic xerollic
MO	Mollic
NA06	Natric
OC	Ochreptic
OR	Orthidic
OR01	Orthic
OR02	Orthoxic
OX	Oxic
PA	Pachic
PA02	Pachic udic
PA04	Pachic ultic
PA08	Paleustollic
PA10	Palexerollic
PE	Pergelic
PE01	Pergelic ruptic-histic
PE02	Pergelic sideric
PE04	Petrocalcic
PE06	Petrocalcic ustalfic
PE08	Petrocalcic ustollic
PE14	Petrocalcic xerollic
PE16	Petroferric
PE20	Petrogypsic
PK	Placic
PK10	Plaggeptic
PK12	Plaggic
PL	Plinthaquic
PL04	Plinthic
PL06	Plinthudic
PS	Psammaquentic
PS02	Psammentic
QU	Quartzipsammentic
RE	Rendollic
RH	Rhodic
RU02	Ruptic-alfic
RU09	Ruptic-lithic
RU11	Ruptic-lithic-entic
RU15	Ruptic-lithic-xerochreptic
RU17	Ruptic-ultic
RU19	Ruptic-vertic
SA	Salorthidic
SA02	Sapric
SA04	Sapric terric
SI	Sideric
SO	Sombric
SP	Sphagnic
SP02	Sphagnic terric
SP04	Spodic
SU	Suflic
TE	Terric
TH04	Thapto-histic
TH06	Thapto-histic tropic
TO	Torrertic
TO02	Torrifluventic
TO04	Torriorthentic
TO06	Torripsammentic
TO10	Torroxic

Classification, Subgroup (cont)

TR	Tropaquodic
TR04	Tropic
UD	Udertic
UD01	Udalfic
UD02	Udic
UD03	Udollic
UD05	Udorthentic
UL	Ultic
UM	Umbreptic
UM02	Umbric
US	Ustalfic
US02	Ustertic
US04	Ustic
US06	Ustochreptic
US08	Ustollic
US12	Ustoxic
VE	Vermic
VE02	Vertic
XA	Xanthic
XE	Xeralfic
XE02	Xerertic
XE04	Xeric
XE08	Xerollic

Classification, Particle Size Class

003	cindery
004	cindery over sandy or sandy-skeletal
005	ashy
006	cindery over loamy
007	ashy over cindery
008	ashy over loamy
009	ashy-skeletal
010	medial
011	medial-skeletal
012	medial over cindery
013	ashy over loamy-skeletal
014	medial over clayey
015	cindery over medial-skeletal
016	medial over fragmental
017	cindery over medial
018	medial over loamy
019	ashy over medial
020	medial over loamy-skeletal
022	medial over sandy or sandy-skeletal
024	medial over thixotropic
026	thixotropic
027	thixotropic-skeletal
028	thixotropic over fragmental
030	thixotropic over sandy or sandy-skeletal
032	thixotropic over loamy-skeletal
034	thixotropic over loamy
036	fragmental
044	sandy-skeletal
046	sandy-skeletal over loamy
050	loamy-skeletal
051	loamy-skeletal over fragmental
052	loamy-skeletal over sandy
054	loamy-skeletal over clayey
055	loamy-skeletal or clayey-skeletal
056	clayey-skeletal
058	clayey-skeletal over sandy
062	sandy
063	sandy or sandy-skeletal
064	sandy over loamy
066	sandy over clayey
068	loamy
072	loamy over sandy or sandy-skeletal
080	coarse-loamy
082	coarse-loamy over fragmental
084	coarse-loamy over sandy or sandy-skeletal
086	coarse-loamy over clayey
088	coarse-silty
092	coarse-silty over sandy or sandy-skeletal
094	coarse-silty over clayey
096	fine-loamy
097	fine-loamy over cindery
098	fine-loamy over fragmental
100	fine-loamy over sandy or sandy-skeletal
102	fine-loamy over clayey
106	fine-silty
108	fine-silty over fragmental
110	fine-silty over sandy or sandy-skeletal
112	fine-silty over clayey
114	clayey
116	clayey over fragmental
118	clayey over sandy or sandy-skeletal
120	clayey over loamy-skeletal
122	clayey over fine-silty
124	clayey over loamy
126	fine
134	very fine

Classification, Mineralogy Class

03	Allitic
05	carbonatic
08	coprogenous
09	chloritic
10	diatomaceous
12	ferrihumic
14	ferritic
16	ferruginous
18	gibbsitic
20	glauconitic
22	gypsic
24	halloysitic
26	illitic
27	illitic (calcareous)
28	kaolinitic
30	marly
32	micaceous
34	mixed
35	mixed (calcareous)
37	montmorillonitic
38	montmorillonitic (calcareous)
40	oxidic
44	serpentinitic
46	siliceous
47	siliceous (calcareous)
48	sesquic
50	vermiculitic

Classification, Reaction Class

04	acid
06	allic
08	dysic
10	euic
12	nonacid
14	noncalcareous

Classification, Temperature Regime

04	frigid
06	hyperthermic
08	isofrigid
10	isohyperthermic
12	isomesic
14	isothermic
16	mesic
18	thermic

Classification, Other Class

04	coated
05	cracked
06	level
08	micro
12	ortstein
14	shallow
15	shallow & uncoated
16	sloping
17	shallow & coated
20	uncoated

Appendix B
Preparation Laboratory Data Forms

Raw and calculated data from samples undergoing analysis at the MASS preparation laboratory are recorded on the data forms presented in this appendix. Examples of the sample labels are also provided. The information on the raw data forms is entered into a personal computer and undergoes data verification.

DIRECT/DELAYED RESPONSE PROJECT (DDRP) SOIL SURVEY
FORM 101

Batch ID ____________
Crew ID ____________
Lab Set Sent to ____________
Date Shipped ____________

Set ID
Date Sampled
Date Received
Date Prep Completed
No. of Samples

Samp No	Set ID	Sample Code	Site ID	Air-dry Moisture %	Field Moist pH	OM-LO1 %	Rock Fragments % 2-4.7	Rock Fragments % 4.7-20	Bulk Dens g/cm3
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
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36									
37									
38									
39									
40									
41									
42									

DIRECT/DELAYED RESPONSE PROJECT (DDRP)
SHIPPING FORM 102

DATE RECEIVED
BY DATA MGT. ___ ___ ___ ___ ___ ___ ___
D D M M M Y Y

Prep Lab ID ______________________
Batch ID ______________________
Analytical ______________________

Date Received ___ ___ ___ ___ ___ ___ ___
Date Shipped ___ ___ ___ ___ ___ ___ ___
D D M M M Y Y

SAMPLE NO.	BULK SAMPLES		PH < 6.5	RETURNED TO LEMSCO (CHECK Y IF YES)
	SHIPPED	RECEIVED		
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				
11				
12				
13				
14				
15				
16				
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36				
37				
38				
39				
40				

Signature of Preparation Laboratory Manager: ______________________
Comments:

FIGURE FORM 102
40

WHITE - SMO   CANARY - ANALYTICAL WITH COPY TO SMO   PINK - ANALYTICAL WITH COPY TO EMSL-LV   GOLD - ANALYTICAL LAB

DDRP Label A

Date Sampled: _ _ _ _ _ _ _
D D M M M Y Y

Crew ID: _ _ _ _

Site ID: _ _ _ _ _ _ _ _

Sample Code: _ _ _ _ _ _ _ _ _ - _ _ _ _

Horizon: _ _ _ _ Depth: _ _ _ - _ _ _ cm.

Set I.D.: _ _ _ _ _

DDRP Label B

Batch ID: _ _ _ _ _

Sample No.: _ _

SOIL SAMPLE RECEIPT FORM

SAM_CODE	CREW ID	SITE ID	SET ID	DATE SAMPLED	DATE SHIPPED	DATE RECEIVED	RECEIVED BY	SAMPLE CONDITION WET/DRY (W/D) BAG SPLIT (B/S) SIEVED/UNSIEVED (S/U) UNDER VOLUME (UV)	CLOD NUMBER	KNOWN VOLUME CAVITY SAMPLE NUMBER	COMMENTS

BULK SAMPLE RAW DATA

SAMPLE ID: _ _ _ _ _ _ _ _ _ _ _ _ DATE SAMPLED: ___/___/___

SITE ID: ______________ DATE REC'D: ___/___/___

SET ID: ______________ PROCESS START: ___/___/___

BATCH ID: ______________ PROCESS COMPLETE: ___/___/___

SOIL TYPE: M/O FIELD pH: ______

Initials: ______ Initials: ______

AIR SAMPLE DRYING:

Date	% Moisture	Initials
___/___	________	______
___/___	________	______
___/___	________	______

TOTAL BULK WT:

Date: ___/___/___ ______.____ g Initials: ______

ROCK FRAGMENT WT:

2 to 4.75 mm: ______.____g 4.75 to 20 mm: ______.____g

Date: ___/____/_____ Initials: ______

ENTERED IN COMPUTER: Date: ____/____/_____ Initials:

COMMENTS:

pH RAW DATA **DATE / /**

SAMPLE CODE	SAMP. #	pH	SAMPLE CODE	SAMP. #	pH
Init QCCS			QCCS		
D			D		
QCCS			QCCS		
D			Final QCCS		

SOIL SAMPLE AIR DRY DETERMINATION

ALL WEIGHTS REPORTED TO 0.01 GRAMS

SAM_CODE	TIN NO.	TIN WT.	AIR DRY (TIN+SOIL)	OVEN DRY (TIN+SOIL)	DATE	ID	COMMENTS

SAMPLE LOSS ON IGNITION DATA

ALL WEIGHTS REPORTED IN 0.01 GRAMS

SAM_CODE	CRUC. NO.	AIR WT.	O. D. WT.	ASHED WT.	DATE	ID	COMMENTS

CLOD BULK DENSITY RAW DATA

ALL WEIGHTS RECORDED TO 0.01 GRAMS

page ___/___

SAM_CODE	REP	FLD_DP	FLD WT moist7dry	LAB_DP	LAB_WT	CLOD_H2O	TEMP C		CRUC NO.	R_FRAG		FLOAT	PROB Y/N	ID	COMMENTS

KNOWN VOLUME BULK DENSITY DATA

ALL WEIGHTS RECORDED TO 0.0 GRAMS

PAGE ___/___

SAM_CODE	AIR_WT	OD_WT	R_FRAG	VOL (cc.)	DATE	ID	COMMENTS

Appendix C

Analytical Parameters in the Mid-Appalachian Soil Survey

Following is a list and description of the analyses that are performed at the preparation laboratory and the analytical laboratories during the MASS. The parameters are described by their data variable name, which is consistent with their presentation in the main text.

Appendix C. Analytical Parameters Measured in the Mid-Appalachian Soil Survey

Parameter	Description of Parameter
PH_MP*	Field-moist pH determined in a deionized water extract using a 1:1 mineral soil to solution ratio and 1:4 organic soil to solution ratio, measured with a pH meter and combination electrode.
MOIST_P*	Air-dry soil moisture measured at the preparation laboratory and expressed as a percentage on an oven-dry weight basis; mineral soils are dried at 105°C, organic soils at 60°C.
OM_LOI*	The percent organic matter content is measured by loss on ignition of an oven-dry sample; a cutoff value of 20 percent organic matter is used to separate mineral soils from organic soils.
RF_FG*	The 2.00- to 4.75-mm fine gravel rock fragments are sieved from the bulk samples and the weight percent is determined gravimetrically.
RF_MG*	The 4.75- to 20.00-mm medium gravel rock fragments are sieved from the bulk samples and the weight percent is determined gravimetrically.
BD_CLD*	The oven-dry soil bulk density, minus rock fragments, of replicate soil clods is determined by a gravimetric displacement method.
BD_KV*	The oven-dry soil bulk density, minus rock fragments, of duplicate known volume samples is determined by a gravimetric replacement method or a gravimetric filling method.
MOIST_A	Air-dry soil moisture measured at the analytical laboratory and expressed as a percentage on an oven-dry weight basis; mineral soils are dried at 105°C, organic soils at 60°C.
SAND	Total sand is the portion of the sample with particle diameter between 0.05 mm and 2.0 mm, and is calculated as the summation of percentages for individual sand fractions: VCOS + COS + MS + FS + VFS.
VCOS	Very coarse sand is the sand fraction between 1.0 mm and 2.0 mm, and is determined by sieving the sand which has been separated from the silt and clay.
COS	Coarse sand is the sand fraction between 0.5 mm and 1.0 mm, and is determined by sieving the sand which has been separated from the silt and clay.
MS	Medium sand is the sand fraction between 0.25 mm and 0.50 mm, and is determined by sieving the sand which has been separated from the silt and clay.
FS	Fine sand is the sand fraction between 0.10 mm and 0.25 mm, and is determined by sieving the sand which has been separated from the silt and clay.
VFS	Very fine sand is the sand fraction between 0.05 mm and 0.10 mm, and is determined by sieving the sand which has been separated from the silt and clay.
SILT	Total silt is the portion of the sample with particle diameter between 0.002 mm and 0.05 mm, and is calculated by subtracting from 100 percent the sum of the total sand and clay.
COSI	Coarse silt is the silt fraction between 0.02 mm and 0.05 mm, and is calculated by subtracting the fine silt fraction from the total silt.
FSI	Fine silt is the silt fraction between 0.002 mm and 0.02 mm; it is determined by pipetting and is calculated by subtracting the clay fraction from the less than 0.02-mm fraction.
CLAY	Total clay is the portion of the sample with particle diameter of less than 0.002 mm; it is determined by pipetting.
PH_H20	pH determined in a deionized water extract using a 1:1 mineral soil to solution ratio or 1:5 organic soil to solution ratio, measured with a pH meter and combination electrode.
PH_002M	pH determined in a 0.002M calcium chloride extract using a 1:2 mineral soil to solution ratio or 1:10 organic soil to solution ratio, measured with a pH meter and combination electrode.

(continued)

Appendix C. Continued

Parameter	Description of Parameter
PH_01M	pH determined in a 0.01M calcium chloride extract using a 1:1 mineral soil to solution ratio or 1:5 organic soil to solution ratio, measured with a pH meter and combination electrode.
CA_CL	Exchangeable calcium determined with an unbuffered 1M ammonium chloride solution; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; atomic absorption spectrometry or inductively coupled plasma atomic emission spectrometry is specified.
MG_CL	Exchangeable magnesium determined with an unbuffered 1M ammonium chloride solution; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; atomic absorption spectrometry or inductively coupled plasma atomic emission spectrometry is specified.
K_CL	Exchangeable potassium determined with an unbuffered 1M ammonium chloride solution; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; atomic absorption spectrometry or flame emission photometry is specified.
NA_CL	Exchangeable sodium determined with an unbuffered 1M ammonium chloride solution; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; atomic absorption spectrometry, inductively coupled plasma atomic emission spectrometry, or flame emission photometry is specified.
AL_CL	Exchangeable aluminum determined with an unbuffered 1M ammonium chloride solution; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; inductively coupled plasma atomic emission spectrometry is specified.
CA_OAC	Exchangeable calcium determined with 1M ammonium acetate solution buffered at pH 7.0; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; atomic absorption spectrometry or inductively coupled plasma atomic emission spectrometry is specified.
MG_OAC	Exchangeable magnesium determined with 1M ammonium acetate solution buffered at pH 7.0; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; atomic absorption spectrometry or inductively coupled plasma atomic emission spectrometry is specified.
K_OAC	Exchangeable potassium determined with 1M ammonium acetate solution buffered at pH 7.0; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; atomic absorption spectrometry or flame emission photometry is specified.
NA_OAC	Exchangeable sodium determined with 1M ammonium acetate solution buffered at pH 7.0; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; atomic absorption spectrometry, inductively coupled plasma atomic emission spectrometry, or flame emission photometry is specified.
CEC_CL	Cation exchange capacity determined with an unbuffered 1M ammonium chloride solution is the effective CEC which occurs at approximately the field pH when combined with the acidity component; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; samples are analyzed for ammonium content by one of three methods: automated distillation/titration; manual distillation/automated titration; or ammonium displacement/flow injection analysis.
CEC_OAC	Cation exchange capacity determined with 1M ammonium acetate solution buffered at pH 7.0 is the theoretical estimate of the maximum potential CEC for a specific soil when combined with the acidity component; approximately 1:26 mineral soil to solution ratio or 1:52 organic soil to solution ratio are used; samples are analyzed for ammonium content by one of three methods: automated distillation/titration; manual distillation/automated titration; or ammonium displacement/flow injection analysis.
AC_BACL	Total exchangeable acidity determined by titration in a buffered (pH 8.2) barium chloride triethanolamine extraction using an approximately 1:30 soil to solution ratio.
CA_CL2	Extractable calcium determined by a 0.002M calcium chloride extraction; a 1:2 mineral soil to solution ratio or 1:10 organic soil to solution ratio are used; the calcium is used to calculate lime potential; atomic absorption spectrometry or inductively coupled plasma atomic emission spectrometry is specified.

(continued)

Appendix C. Continued

Parameter	Description of Parameter
MG_CL2	Extractable magnesium determined by a 0.002M calcium chloride extraction; a 1:2 mineral soil to solution ratio or 1:10 organic soil to solution ratio are used; atomic absorption spectrometry or inductively coupled plasma atomic emission spectrometry is specified.
K_CL2	Extractable potassium determined by a 0.002M calcium chloride extraction; a 1:2 mineral soil to solution ratio or 1:10 organic soil to solution ratio are used; atomic absorption spectrometry or flame emission photometry is specified.
NA_CL2	Extractable sodium determined by a 0.002M calcium chloride extraction; a 1:2 mineral soil to solution ratio or 1:10 organic soil to solution ratio are used; atomic absorption spectrometry, inductively coupled plasma atomic emission spectrometry, or flame emission photometry is specified.
FE_CL2	Extractable iron determined by a 0.002M calcium chloride extraction; a 1:2 mineral soil to solution ratio or 1:10 organic soil to solution ratio are used; inductively coupled plasma atomic emission spectrometry is specified.
AL_CL2	Extractable aluminum determined by a 0.002M calcium chloride extraction; a 1:2 mineral soil to solution ratio or 1:10 organic soil to solution ratio are used; the aluminum concentration obtained from this procedure is used to calculate aluminum potential; inductively coupled plasma atomic emission spectrometry is specified.
FE_PYP	Extractable iron determined by a 0.1M sodium pyrophosphate extraction using a 1:100 soil to solution ratio; the pyrophosphate extract estimates organically-bound iron; inductively coupled plasma atomic emission spectrometry is specified.
AL_PYP	Extractable aluminum determined by a 0.1M sodium pyrophosphate extraction using a 1:100 soil to solution ratio; the pyrophosphate extract estimates organically-bound aluminum; inductively coupled plasma atomic emission spectrometry is specified.
FE_AO	Extractable iron determined by an ammonium oxalate-oxalic acid extraction using a 1:100 soil to solution ratio; the acid oxalate extract estimates organic and amorphous iron oxides; inductively coupled plasma atomic emission spectrometry is specified.
AL_AO	Extractable aluminum determined by an ammonium oxalate-oxalic acid extraction using a 1:100 soil to solution ratio; the acid oxalate extract estimates organic and amorphous aluminum oxides; inductively coupled plasma atomic emission spectrometry is specified.
SI_AO	Extractable silicon determined by an ammonium oxalate-oxalic acid extraction using a 1:100 soil to solution ratio; inductively coupled plasma atomic emission spectrometry is specified.
FE_CD	Extractable iron determined by a sodium citrate-sodium dithionite extraction using a 1:30 soil to solution ratio; the citrate dithionite extract estimates non-silicate iron; inductively coupled plasma atomic emission spectrometry is specified.
AL_CD	Extractable aluminum determined by a sodium citrate-sodium dithionite extraction using a 1:30 soil to solution ratio; the citrate dithionite extract estimates non-silicate aluminum; inductively coupled plasma atomic emission spectrometry is specified.
SO4_H2O	Extractable sulfate determined with a double deionized water extract; this extraction approximates the sulfate which will readily enter the soil solution and uses a 1:40 soil to solution ratio; ion chromatography is specified.
SO4_PO4	Extractable sulfate determined with a 0.016M sodium phosphate (500 mg P/L) extract; this extraction approximates the total amount of adsorbed sulfate and uses a 1:40 soil to solution ratio; ion chromatography is specified.
SO4_0	Sulfate remaining in a 0 mg S/L solution following equilibration with a 1:5 mineral soil to solution ratio or 1:20 organic soil to solution ratio; the data are used to develop sulfate isotherms; ion chromatography is specified.

(continued)

Appendix C. Continued

Parameter	Description of Parameter
SO4_2	Sulfate remaining in a 2 mg S/L solution following equilibration with a 1:5 mineral soil to solution ratio or 1:20 organic soil to solution ratio; the data are used to develop sulfate isotherms; ion chromatography is specified.
SO4_4	Sulfate remaining in a 4 mg S/L solution following equilibration with a 1:5 mineral soil to solution ratio or 1:20 organic soil to solution ratio; the data are used to develop sulfate isotherms; ion chromatography is specified.
SO4_8	Sulfate remaining in a 8 mg S/L solution following equilibration with a 1:5 mineral soil to solution ratio or 1:20 organic soil to solution ratio; the data are used to develop sulfate isotherms; ion chromatography is specified.
SO4_16	Sulfate remaining in a 16 mg S/L solution following equilibration with a 1:5 mineral soil to solution ratio or 1:20 organic soil to solution ratio; the data are used to develop sulfate isotherms; ion chromatography is specified.
SO4_32	Sulfate remaining in a 32 mg S/L solution following equilibration with a 1:5 mineral soil to solution ratio or 1:20 organic soil to solution ratio; the data are used to develop sulfate isotherms; ion chromatography is specified.
C_TOT	Total carbon determined by rapid oxidation followed by infrared detection or thermal conductivity detection using an automated CHN analyzer; total carbon can be used to characterize the soil organic matter.
N_TOT	Total nitrogen determined by rapid oxidation followed by infrared detection or thermal conductivity detection using an automated CHN analyzer; total nitrogen can be used to characterize the soil organic matter.
S_TOT	Total sulfur determined by automated sample combustion followed by infrared detection of evolved sulfur dioxide.

* This parameter is measured at the preparation laboratory

Appendix D

Analytical Laboratory Verification Criteria

The following QC criteria and data reporting forms are used by the LEVIS programs to evaluate the results of laboratory analysis. The results are obtained using the analytical procedures detailed in the Analytical Laboratory Statements of Work. The raw data are entered into LEVIS, calculations are performed, and summary reports are generated for review by the analytical laboratories.

CRITERIA FOR QUALITY CONTROL SUMMARY CHECKS
(FLAG IF THESE CRITERIA ARE NOT MET)

Summary Page 1 - NA	
Summary Page 2 - NA	
Summary Page 3	
Replicate Evaluation	All pH Parameters and all Particle Size parameters, calculated SD <= SD from the RED form, All other parameters, calculated SD <= SD from the RED form if the mean of the reps. is < the KNOT from the RED form and calculated %RSD <= RSD from the RED form if the mean is >= the KNOT from the RED form.
Summary Page 4	
Spike Recovery	All Sulfate Isotherms, 95% <= x <= 105% All other parameters, 90% <= x <= 110%
Summary Page 5	
Reagent Blank Mean	FINE SILT + CLAY parameter - no check, All pH parameters, 4.5 <= Mean <= 7.5, AC_BACL, 1.300 <= Mean <= 1.800 meq, CA_CL2, 76 <= Mean <= 84, (+/- 5%) SO4_0 <= CRDL, SO4_2, 1.94 <= Mean <= 2.06, (+/- 3%) SO4_4, 3.88 <= Mean <= 4.12, (+/- 3%) SO4_8, 7.76 <= Mean <= 8.24, (+/- 3%) SO4_16,15.52 <= Mean <= 16.48, (+/- 3%) SO4_32,31.36 <= Mean <= 32.64, (+/- 2%) All other parameters, <= CRDL from the CRD Form.
Summary Page 6	
QCCS - True	Report True value from QC Form
QCCS - No. Run	Particle Size (SAND, SILT and CLAY only), 1 or more, All other parameters, (Ceiling of (# Samples in Batch/10))+1.

(continued)

QCCS - No. of Out of Range (Report number of QCCS not meeting the criteria)	All Sulfate Isotherms, QCCS within +/- 5% of the True QCCS form the QC Form, All other parameters, QCCS within +/- 10% of the True QCCS from the QC Form.
DLQCCS - True	Report DLQCCS value from the QC Form.
DLQCCS - Meas.	Within +/- 20% of the True DLQCCS from the QC Form.
Calib. Blank - No. Run	(Ceiling of (# Samples in Batch/10))+1.
Calib. Blank - No. of Out of Range (Report number of Calib. Blanks not meeting criteria)	AC_BACL, 26.0 <= Calib. Blank <= 36.0 mL All other parameters, <= CRDL from the CRD Form.
QA Check Sample	Sample Result between High/Low range. (range supplied on the summary page)

Summary Page 7 - NA

Summary Page 8

All samples in a batch must meet these Criteria or a flag is set.

Sample Wt. Check	Particle Size - Measured Sample Wt. 10 +/- 5% or 20 +/- 5%, All other parameters - Measured Sample Wt. between Method Wt. +/- 5%
Sample Vol. Check	Measured Sample Vol. = Method Vol.

Summary Page 9

Spike Solution Check	Each Inst. Reading between: CA_CL2, 76 <= x <= 84, (80 +/- 5%) SO4_0 <= CRDL, SO4_2, 1.94 <= Mean <= 2.06, (+/- 3%) SO4_4, 3.88 <= Mean <= 4.12, (+/- 3%) SO4_8, 7.76 <= Mean <= 8.24, (+/- 3%) SO4_16,15.52 <= Mean <= 16.48, (+/- 3%) SO4_32,31.36 <= Mean <= 32.64, (+/- 2%)

Summary Page 10

Instrument Detection Limit	<= the CRDL from the CRD Form.

SOIL CHEMISTRY RELATIONSHIPS

Simple mathematical relationships are used to examine the soil chemistry of data for each sample. For each SCR, it is expected that approximately 10 percent of the data may not comply with these relationships. These anomalous data are examined by a soil chemist who qualifies them or assigns appropriate flags. The following SCRs are examined in qualifying the data:

(1) The analytical laboratory pH values should relate as follows:

PH_01M < PH_002M < PH_H20
if pH differences are > 0.05 units

$CaCl_2$ solution masks the effect of soluble salts in soils; Ca^{2+} ions displace H^+ ions from exchange sites; the H^+ ion concentration in solution increases, resulting in the measurement of lower pH.

(2) The cation exchange capacity parameters should relate as follows:

CEC_CL < CEC_OAC
if CEC_CL > 1meq/100g and PH_H20 < 7.0

A higher CEC is measured by using a buffered (pH 7) NH_4OAc saturating solution to determine CEC in an acid soil. With an increase in pH, hydrogen ions are displaced. This creates more exchange sites for retention of NH_4^+. The NH_4Cl saturating solution is unbuffered; therefore, cation exchange takes place nearer the soil pH, resulting in the measurement of lower CEC.

(3) The exchangeable cations and CEC should relate as follows:

CA_OAC + MG_OAC + K_OAC + NA_OAC < CEC_OAC
if CEC_CL > 1meq/100g

CA_CL + MG_CL + K_CL + NA_CL < CEC_CL
if CEC_CL > 1meq/100g

The total CEC is made up of all cations adsorbed on the surface of the clay minerals and organic matter, including Ca, Mg, K, Na, Al, and H. Therefore the addition of the base cations excluding the acid Al and H should be less than the total capacity of the soil to hold cations.

(4) The relationship between CEC and the percent clay is as follows:

CEC_OAC/CLAY < 50
if CLAY > 1.0 and CEC_CL > 1meq/100g

CEC_CL/CLAY < 50
if CLAY > 1.0 and CEC_CL > 1meq/100g

Clay mineralogy is a major factor in predicting CEC in soils. The theoretical maximum CEC value for vermiculite clay (which has the highest CEC values) is 180 meq/100g and the highest clay content in soil samples from previous DDRP surveys is 36 percent. Because the percent clay and vermiculite content of the MASS soils are expected to be lower than the highest values from previous surveys, this relationship should hold.

(5) The extractable sulfates should relate as follows:

SO4_H2O < SO4_SO4
if SO4_PO4 > 1mgS/kg soil

The phosphate extractable solution estimates the total adsorbed sulfate; water extractable solution estimates the sulfate which readily enters soil solution.

(6) The relationships between the sulfate isotherms is as follows:

SO4_0N < SO4_2N < SO4_4N < SO4_8N < SO4_16N < SO4_32N
if SO4_32N >= 7.5 mg S/kg soil

The adsorption isotherms for sulfate should be greater as more sulfate is added to the soils for potential adsorption onto the anion exchange complexes.

(7) The relationships between the sulfate isotherms is as follows:

SO4_0 < SO4_2 < SO4_4 < SO4_8 < SO4_16 < SO4_32
if SO4_32N <= 7.5 mg S/kg soil

The adsorption isotherms for sulfate should be greater as more sulfate is added to the soils for potential adsorption onto the anion exchange complexes.

(8) The ratio of water-extractable sulfate and the zero sulfate isotherm is as follows:

4 < SO4_H2O/SO4_0 < 20
if SO4_H2O >= 2mgS/kg and SO4_0 >= 0.1 mgS/kg

This is based on the theoretical relationship between the two different extraction methods and provides a check on the extraction procedures.

(9) The relationship between the calcium chloride extracted cations and the ammonium chloride exchangeable cations is as follows:

NA_CL2 < NA_CL * 1.10
if NA_CL2 > 0.03meq/100g

K_CL2 < K_CL * 1.10
if K_CL2 > 0.003meq/100g

MG_CL2 < MG_CL * 1.10
if MG_CL2 > 0.008meq/100g

The extraction of these three cations by NH_4Cl is an exhaustive extraction while the extraction of the cations by $CaCl_2$ is done with a much more dilute extraction agent and will result in a nearly complete extraction of the cation. Therefore by increasing the NH_4Cl extracted cation by a factor of 1.10 (chosen to include 10% error during the extraction procedure) should be greater than the $CaCl_2$ extracted cations.

(10) The relationships of total carbon, nitrogen, and sulfur should relate as follows:

7 < C_TOT/N_TOT < 50
if C_TOT >= 0.1% and N_TOT >= 0.03%

40 < C_TOT/S_TOT < 400
if C_TOT >= 0.1% and S_TOT >= 0.005%

The ratios are based on common C:N and C:S relationships found in previous surveys and should hold for all except the lowest concentration samples.

QC Summary Report
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Number of Observations
and Submission Selection

Batch # ____
Date Run __/__/__

Number of Samples in Batch __

	Submission #	1	_	_	_	_	_	_	_
	Run #	1	_	_	_	_	_	_	_
		Number of Observations and Submission Selection							
Form #	Parameter	xx *	xx *	xx *	xx *	xx *	xx *	xx *	xx *
01	MOIST								
03	SAND								
03	SILT								
03	CLAY								
03	VCOS								
03	COS								
03	MS								
03	FS								
03	VFS								
03	COSI								
03	FSI								
04	PH_H2O								
05	PH_01M								
06A/B	CEC_OAC								
07A/B	CEC_CL								
08	CA_OAC								
09	MG_OAC								
10	K_OAC								
11	NA_OAC								
12	CA_CL								
13	MG_CL								
14	K_CL								
15	NA_CL								
16	AL_CL								
17	AC_BACL								
18	PH_002M								
19	CA_CL2								
20	MG_CL2								
21	K_CL2								
22	NA_CL2								
23	FE_CL2								
24	AL_CL2								
25	FE_PYP								
26	AL_PYP								
27	FE_AO								
28	AL_AO								
29	SI_AO								
30	FE_CD								
31	AL_CD								
32	SO4_H2O								
33	SO4_PO4								
34	SO4_0								
35	SO4_2								
36	SO4_4								
37	SO4_8								
38	SO4_16								
39	SO4_32								
40	C_TOT								
41	N_TOT								
42	S_TOT								

"*" Denotes the Run # selected for submission.

QC Summary Report
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Range Checks

Batch # ___
Date Run _/_/_

Number of Samples in Batch __

Form #	Parameter	Units	Number of Obs. xx	Minimum Value xxx.xxxx	Maximum Value xxx.xxxx	Mean Value xxx.xxxx
01	MOIST	wt. %				
03	SAND	wt. %				
03	SILT	wt. %				
03	CLAY	wt. %				
03	VCOS	wt. %				
03	COS	wt. %				
03	MS	wt. %				
03	FS	wt. %				
03	VFS	wt. %				
03	COSI	wt. %				
03	FSI	wt. %				
04	PH_H2O	pH units				
05	PH_01M	pH units				
06A/B	CEC_OAC	meq/100g				
07A/B	CEC_CL	meq/100g				
08	CA_OAC	meq/100g				
09	MG_OAC	meq/100g				
10	K_OAC	meq/100g				
11	NA_OAC	meq/100g				
12	CA_CL	meq/100g				
13	MG_CL	meq/100g				
14	K_CL	meq/100g				
15	NA_CL	meq/100g				
16	AL_CL	meq/100g				
17	AC_BACL	meq/100g				
18	PH_002M	pH units				
19	CA_CL2	meq/100g				
20	MG_CL2	meq/100g				
21	K_CL2	meq/100g				
22	NA_CL2	meq/100g				
23	FE_CL2	meq/100g				
24	AL_CL2	meq/100g				
25	FE_PYP	wt. %				
26	AL_PYP	wt. %				
27	FE_AO	wt. %				
28	AL_AO	wt. %				
29	SI_AO	wt. %				
30	FE_CD	wt. %				
31	AL_CD	wt. %				
32	SO4_H2O	mg S/kg				
33	SO4_PO4	mg S/kg				
34	SO4_0	mg S/L				
35	SO4_2	mg S/L				
36	SO4_4	mg S/L				
37	SO4_8	mg S/L				
38	SO4_16	mg S/L				
39	SO4_32	mg S/L				
40	C_TOT	wt. %				
41	N_TOT	wt. %				
42	S_TOT	wt. %				

QC Summary Report
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Replicate Evaluation

Batch # ______
Date Run __/__/__

Form #	Parameter	SD or % RSD and Flag		
		1st xxx.xxx * (S/R)	2nd xxx.xxx * (S/R)	3rd xxx.xxx * (S/R)
01	MOIST			
03	SAND			
03	SILT			
03	CLAY			
04	PH_H2O			
05	PH_01M			
06A/B	CEC_OAC			
07A/B	CEC_CL			
08	CA_OAC			
09	MG_OAC			
10	K_OAC			
11	NA_OAC			
12	CA_CL			
13	MG_CL			
14	K_CL			
15	NA_CL			
16	AL_CL			
17	AC_BACL			
18	PH_002M			
19	CA_CL2			
20	MG_CL2			
21	K_CL2			
22	NA_CL2			
23	FE_CL2			
24	AL_CL2			
25	FE_PYP			
26	AL_PYP			
27	FE_AO			
28	AL_AO			
29	SI_AO			
30	FE_CD			
31	AL_CD			
32	SO4_H2O			
33	SO4_PO4			
34	SO4_0			
35	SO4_2			
36	SO4_4			
37	SO4_8			
38	SO4_16			
39	SO4_32			
40	C_TOT			
41	N_TOT			
42	S_TOT			

"*" In column indicates a problem with that parameter.
"S" In column indicates the reported value is the standard deviation.
"R" In column indicates the reported value is the % RSD.

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Percent Spike Recovery

Batch # ____
Date Run __/__/__

Form #	Parameter	% Spike Recovery and Flag		
		1st xxx.xx *	2nd xxx.xx *	3rd xxx.xx *
01	MOIST	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
02	Particle Size	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
03	Particle Size	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
04	PH_H2O	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
05	PH_01M	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
06A/B	CEC_OAC			
07A/B	CEC_CL			
08	CA_OAC			
09	MG_OAC			
10	K_OAC			
11	NA_OAC			
12	CA_CL			
13	MG_CL			
14	K_CL			
15	NA_CL			
16	AL_CL			
17	AC_BACL	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
18	PH_002M	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
19	CA_CL2			
20	MG_CL2			
21	K_CL2			
22	NA_CL2			
23	FE_CL2			
24	AL_CL2			
25	FE_PYP			
26	AL_PYP			
27	FE_AO			
28	AL_AO			
29	SI_AO			
30	FE_CD			
31	AL_CD			
32	SO4_H2O			
33	SO4_PO4			
34	SO4_0	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
35	SO4_2 (1)			
	(2)			
36	SO4_4	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
37	SO4_8 (1)			
	(2)			
38	SO4_16	XXXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
39	SO4_32 (1)			
	(2)			
40	C_TOT			
41	N_TOT			
42	S_TOT			

"*" In column indicates a problem with that parameter.

QC Summary Report
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Reagent Blanks

Batch # ____
Date Run __/__/__

Form #	Parameter	Reagent Blank and Flag				
		Units	1st xxx.xxx	2nd xxx.xxx	3rd xxx.xxx	Mean xxx.xxx *
01	MOIST	XXXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXXXX
02	FSI + CLAY	g		XXXXXXXXX	XXXXXXXXX	
04	PH_H2O	pH units		XXXXXXXXX	XXXXXXXXX	
05	PH_01M	pH units		XXXXXXXXX	XXXXXXXXX	
06A/B	CEC_OAC	mg N/L or meq				
07A/B	CEC_CL	mg N/L or meq				
08	CA_OAC	mg/L				
09	MG_OAC	mg/L				
10	K_OAC	mg/L				
11	NA_OAC	mg/L				
12	CA_CL	mg/L				
13	MG_CL	mg/L				
14	K_CL	mg/L				
15	NA_CL	mg/L				
16	AL_CL	mg/L				
17	AC_BACL	meq				
18	PH_002M	pH units		XXXXXXXXX	XXXXXXXXX	
19	CA_CL2	mg/L				
20	MG_CL2	mg/L				
21	K_CL2	mg/L				
22	NA_CL2	mg/L				
23	FE_CL2	mg/L				
24	AL_CL2	mg/L				
25	FE_PYP	mg/L				
26	AL_PYP	mg/L				
27	FE_AO	mg/L				
28	AL_AO	mg/L				
29	SI_AO	mg/L				
30	FE_CD	mg/L				
31	AL_CD	mg/L				
32	SO4_H2O	mg S/L				
33	SO4_PO4	mg S/L				
34	SO4_0	mg S/L				
35	SO4_2	mg S/L				
36	SO4_4	mg S/L				
37	SO4_8	mg S/L				
38	SO4_16	mg S/L				
39	SO4_32	mg S/L				
40	C_TOT	wt. %				
41	N_TOT	wt. %				
42	S_TOT	wt. %				

"*" In column indicates a problem with that parameter.

QC Summary Report
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QCCS, DLQCCS, and Calibration Blank

Batch # ___
Date Run __/__/__

Number of Samples in Batch __

		QCCS			DLQCCS		Calib. Blank	
Form #	Parameter	True Value xxx.xxx	No. Run x *	No.Out Range x	True Value xxx.xxx	Meas. *	No. Run x *	No.Out Range x
01	MOIST	XXXXXXXXX	XXXXX	XXXXXX	XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	SAND				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	SILT				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	CLAY				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	VCOS				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	COS				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	MS				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	FS				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	VFS				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	COSI				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
03	FSI				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
04	PH_H2O				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
05	PH_01M				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
06A/B	CEC_OAC							
07A/B	CEC_CL							
08	CA_OAC							
09	MG_OAC							
10	K_OAC							
11	NA_OAC							
12	CA_CL							
13	MG_CL							
14	K_CL							
15	NA_CL							
16	AL_CL							
17	AC_BACL							
18	PH_002M				XXXXXXXXX	XXXXXXX	XXXXX	XXXXXX
19	CA_CL2							
20	MG_CL2							
21	K_CL2							
22	NA_CL2							
23	FE_CL2							
24	AL_CL2							
25	FE_PYP							
26	AL_PYP							
27	FE_AO							
28	AL_AO							
29	SI_AO							
30	FE_CD							
31	AL_CD							
32	SO4_H2O							
33	SO4_PO4							
34	SO4_0							
35	SO4_2						XXXXX	XXXXXX
36	SO4_4						XXXXX	XXXXXX
37	SO4_8						XXXXX	XXXXXX
38	SO4_16						XXXXX	XXXXXX
39	SO4_32						XXXXX	XXXXXX
40	C_TOT							
41	N_TOT							
42	S_TOT							

"*" In column indicates a problem with that parameter.

QC Summary Report
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QA Check Sample Results

Batch # ___
Date Run __/__/__

Form #	Parameter	Low Range Value xxx.xxx	Sample Result Value xxx.xxx *	High Range Value xxx.xxx
01	MOIST	xxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxx
03	SAND	51.159		62.397
03	SILT	19.059		31.068
03	CLAY	16.567		19.999
03	VCOS	0.426		1.346
03	COS	2.602		3.631
03	MS	7.650		8.904
03	FS	19.831		27.371
03	VFS	17.460		24.373
03	COSI	8.232		13.639
03	FSI	11.349		17.250
04	PH_H2O	4.440		4.606
05	PH_01M	3.890		4.133
06A/B	CEC_OAC	15.107		20.440
07A/B	CEC_CL	6.645		8.991
08	CA_OAC	0.222		0.306
09	MG_OAC	0.187		0.277
10	K_OAC	0.224		0.280
11	NA_OAC	0.014		0.058
12	CA_CL	0.239		0.323
13	MG_CL	0.181		0.247
14	K_CL	0.208		0.289
15	NA_CL	0.0002		0.074
16	AL_CL	xxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxx
17	AC_BACL	15.119		22.676
18	PH_002M	4.140		4.310
19	CA_CL2	0.336		0.486
20	MG_CL2	0.087		0.171
21	K_CL2	0.038		0.089
22	NA_CL2	0.022		0.039
23	FE_CL2	0.011		0.028
24	AL_CL2	0.027		0.141
25	FE_PYP	0.543		0.735
26	AL_PYP	0.518		0.701
27	FE_AO	0.350		0.474
28	AL_AO	0.341		0.511
29	SI_AO	xxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxx
30	FE_CD	1.456		2.184
31	AL_CD	0.423		0.572
32	SO4_H2O	25.143		35.548
33	SO4_PO4	64.396		87.778
34	SO4_0	3.884		4.514
35	SO4_2	5.183		6.024
36	SO4_4	6.505		7.560
37	SO4_8	9.310		10.820
38	SO4_16	15.221		17.689
39	SO4_32	27.567		32.038
40	C_TOT	4.261		5.041
41	N_TOT	0.122		0.191
42	S_TOT	0.0164		0.0194

"*" In column indicates a problem with that parameter.

QC Summary Report
Page 8 of 10

Wt. and Vol. Check

Batch # ___
Date Run __/__/__

Form #	Parameter	Method Wt. (g)	Measured Wt. *	Method Vol. (mL)	Measured Vol. *
01	MOIST	10.0		XXXXXXXX	XXXXXXXXXX
02	Particle Size	10,20.0		XXXXXXXX	XXXXXXXXXX
03	Particle Size	XXXXXXXX	XXXXXXXXXX	XXXXXXXX	XXXXXXXXXX
04	PH_H2O	20.0		20.0	
05	PH_01M	20.0		20.0	
06A/B	CEC_OAC	5.0		XXXXXXXX	XXXXXXXXXX
07A/B	CEC_CL	5.0		XXXXXXXX	XXXXXXXXXX
08	CA_OAC	5.0		XXXXXXXX	XXXXXXXXXX
09	MG_OAC	5.0		XXXXXXXX	XXXXXXXXXX
10	K_OAC	5.0		XXXXXXXX	XXXXXXXXXX
11	NA_OAC	5.0		XXXXXXXX	XXXXXXXXXX
12	CA_CL	5.0		XXXXXXXX	XXXXXXXXXX
13	MG_CL	5.0		XXXXXXXX	XXXXXXXXXX
14	K_CL	5.0		XXXXXXXX	XXXXXXXXXX
15	NA_CL	5.0		XXXXXXXX	XXXXXXXXXX
16	AL_CL	5.0		XXXXXXXX	XXXXXXXXXX
17	AC_BACL	2.0		XXXXXXXX	XXXXXXXXXX
18	PH_002M	20.0		40.0	
19	CA_CL2	20.0		40.0	
20	MG_CL2	20.0		40.0	
21	K_CL2	20.0		40.0	
22	NA_CL2	20.0		40.0	
23	FE_CL2	20.0		40.0	
24	AL_CL2	20.0		40.0	
25	FE_PYP	2.0		204.0	
26	AL_PYP	2.0		204.0	
27	FE_AO	2.0		204.0	
28	AL_AO	2.0		204.0	
29	SI_AO	2.0		204.0	
30	FE_CD	4.0		129.0	
31	AL_CD	4.0		129.0	
32	SO4_H2O	4,2.0		80,40.0	
33	SO4_PO4	5,2.5		100,50.0	
34	SO4_0	10,5.0		50,25.0	
35	SO4_2	10,5.0		50,25.0	
36	SO4_4	10,5.0		50,25.0	
37	SO4_8	10,5.0		50,25.0	
38	SO4_16	10,5.0		50,25.0	
39	SO4_32	10,5.0		50,25.0	
40	C_TOT	0.1,0.02		XXXXXXXX	XXXXXXXXXX
41	N_TOT	0.1,0.02		XXXXXXXX	XXXXXXXXXX
42	S_TOT	0.8, 0.3		XXXXXXXX	XXXXXXXXXX

"*" In column indicates a problem with that parameter.

QC Summary Report
Page 9 of 10

Spike Solution Check

Batch # ____
Date Run __/__/__

0 mg S/L Isotherm	
Theor. Value (mg S/L)	Inst. Reading (mg S/L) *
0.00	
0.00	
0.00	

2 mg S/L Isotherm	
Theor. Value (mg S/L)	Inst. Reading (mg S/L) *
2.00	
2.00	
2.00	

4 mg S/L Isotherm	
Theor. Value (mg S/L)	Inst. Reading (mg S/L) *
4.00	
4.00	
4.00	

8 mg S/L Isotherm	
Theor. Value (mg S/L)	Inst. Reading (mg S/L) *
8.00	
8.00	
8.00	

16 mg S/L Isotherm	
Theor. Value (mg S/L)	Inst. Reading (mg S/L) *
16.00	
16.00	
16.00	

32 mg S/L Isotherm	
Theor. Value (mg S/L)	Inst. Reading (mg S/L) *
32.00	
32.00	
32.00	

CA_CL2	
Theor. Value (mg/L)	Inst. Reading (mg/L) *
80.00	
80.00	
80.00	

"*" In column indicates a problem with the parameter.

QC Summary Report
Page 10 of 10

Detection Limits

Batch # ____
Date Run _/_/_

Form #	Parameter	Calculated Reporting Units	Contract Required Detection Limit	Instrument Detection Limit *	Date Determined (MM/DD/YY)
01	MOIST	XXXXXXXXXXXX	XXXXXXXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
02	Particle Size	XXXXXXXXXXXX	XXXXXXXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
03	Particle Size	XXXXXXXXXXXX	XXXXXXXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
04	PH_H2O	XXXXXXXXXXXX	XXXXXXXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
05	PH_01M	XXXXXXXXXXXX	XXXXXXXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
06A	CEC_OAC (FIA)	meq/100g	1.050 mg N/L		
06B	CEC_OAC (Tit.)	meq/100g	0.0075 meq **		
07A	CEC_CL (FIA)	meq/100g	1.050 mg N/L		
07B	CEC_CL (Tit.)	meq/100g	0.0075 meq **		
08	CA_OAC	meq/100g	0.050 mg/L		
09	MG_OAC	meq/100g	0.050 mg/L		
10	K_OAC	meq/100g	0.050 mg/L		
11	NA_OAC	meq/100g	0.050 mg/L		
12	CA_CL	meq/100g	0.050 mg/L		
13	MG_CL	meq/100g	0.050 mg/L		
14	K_CL	meq/100g	0.050 mg/L		
15	NA_CL	meq/100g	0.050 mg/L		
16	AL_CL	meq/100g	0.100 mg/L		
17	AC_BACL	meq/100g	0.005 meq		
18	PH_002M	XXXXXXXXXXXX	XXXXXXXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
19	CA_CL2	meq/100g	0.500 mg/L		
20	MG_CL2	meq/100g	0.050 mg/L		
21	K_CL2	meq/100g	0.050 mg/L		
22	NA_CL2	meq/100g	0.050 mg/L		
23	FE_CL2	meq/100g	0.100 mg/L		
24	AL_CL2	meq/100g	0.100 mg/L		
25	FE_PYP	wt. %	0.500 mg/L		
26	AL_PYP	wt. %	0.500 mg/L		
27	FE_AO	wt. %	0.500 mg/L		
28	AL_AO	wt. %	0.500 mg/L		
29	SI_AO	wt. %	0.500 mg/L		
30	FE_CD	wt. %	0.500 mg/L		
31	AL_CD	wt. %	0.500 mg/L		
32	SO4_H2O	mg S/kg	0.025 mg S/L		
33	SO4_PO4	mg S/kg	0.025 mg S/L		
34	SO4_0	mg S/L	0.025 mg S/L		
35	SO4_2	mg S/L	0.025 mg S/L		
36	SO4_4	mg S/L	0.025 mg S/L		
37	SO4_8	mg S/L	0.025 mg S/L		
38	SO4_16	mg S/L	0.025 mg S/L		
39	SO4_32	mg S/L	0.025 mg S/L		
40	C_TOT	wt. %	0.010 wt. %		
41	N_TOT	wt. %	0.005 wt. %		
42	S_TOT	wt. %	0.001 wt. %		

"*" In column indicates a problem with that parameter.
** For titrations, the instrumental detection limit is a calculated value based upon a minimum titration.

Form Descriptions Sorted by Form #

Form #	Form Type	Parameter	Description
01	0	MOIST	Air Dry Moisture Percent
02	10	Particle Size Raw	Particle Size (Raw Data)
03	11	Particle Size Calc.	Particle Size (Calculated Data)
04	8	PH_H2O	pH in Water
05	8	PH_01M	pH in 0.01M Calcium Chloride
06A	2	CEC_OAC (FIA)	Cation Exchange Capacity - Ammonium Acetate
06B	6	CEC_OAC (Titr.)	Cation Exchange Capacity - Ammonium Acetate
07A	2	CEC_CL (FIA)	Cation Exchange Capacity - Ammonium Chloride
07B	6	CEC_CL (Titr.)	Cation Exchange Capacity - Ammonium Chloride
08	2	CA_OAC	Calcium in Ammonium Acetate
09	2	MG_OAC	Magnesium in Ammonium Acetate
10	2	K_OAC	Potassium in Ammonium Acetate
11	2	NA_OAC	Sodium in Ammonium Acetate
12	2	CA_CL	Calcium in Ammonium Chloride
13	2	MG_CL	Magnesium in Ammonium Chloride
14	2	K_CL	Potassium in Ammonium Chloride
15	2	NA_CL	Sodium in Ammonium Chloride
16	2	AL_CL	Aluminum in Ammonium Chloride
17	7	AC_BACL	Barium Chloride - TEA Acidity
18	8	PH_002M	pH in 0.002M Calcium Chloride
19	1	CA_CL2	Calcium in Calcium Chloride
20	1	MG_CL2	Magnesium in Calcium Chloride
21	1	K_CL2	Potassium in Calcium Chloride
22	1	NA_CL2	Sodium in Calcium Chloride
23	1	FE_CL2	Iron in Calcium Chloride
24	1	AL_CL2	Aluminum in Calcium Chloride
25	3	FE_PYP	Pyrophosphate Extractable Iron
26	3	AL_PYP	Pyrophosphate Extractable Aluminum
27	3	FE_AO	Acid Oxalate Extractable Iron
28	3	AL_AO	Acid Oxalate Extractable Aluminum
29	3	SI_AO	Acid Oxalate Extractable Silicon
30	3	FE_CD	Citrate Dithionite Extractable Iron
31	3	AL_CD	Citrate Dithionite Extractable Aluminum
32	4	SO4_H2O	Water Extractable Sulfate
33	4	SO4_PO4	Phosphate Extractable Sulfate
34	5	SO4_0	Zero mg S/L Isotherm Parameter
35	5	SO4_2	Two mg S/L Isotherm Parameter
36	5	SO4_4	Four mg S/L Isotherm Parameter
37	5	SO4_8	Eight mg S/L Isotherm Parameter
38	5	SO4_16	Sixteen mg S/L Isotherm Parameter
39	5	SO4_32	Thirty-two mg S/L Isotherm Parameter
40	9	C_TOT	Total Carbon
41	9	N_TOT	Total Nitrogen
42	9	S_TOT	Total Sulfur

Appendix E
Analytical Laboratory Pre-Award Evaluation Scoring Sheet

The following format is used to grade each contract laboratory that analyzes pre-award audit samples provided by the QA staff. The scores from this evaluation are used in considering the award of contracts for DDRP analysis.

APPENDIX E

PRE-AWARD PERFORMANCE EVALUATION SCORING SHEET

LABORATORY: ____________________

Quantitation: ____________________

Relationships: ____________________

Quality Control: ____________________

Deliverables: ____________________

TOTAL SCORE: ____________________

PERCENTAGE: ____________________%

DATE: ____________________

Sample 1: ______________

Sample 2: ______________

Sample 3: ______________

Sample 4: ______________

Sample 5: ______________

(Maximum score per sample = 250 points)

PART I. QUANTITATION

Parameter	Possible Points	Points Awarded (Samples) 1	2	3	4	5	Total Score
PH_H2O	3						
PH_002M	3						
PH_01M	3						
SO4_0	3						
SO4_2	3						
SO4_4	3						
SO4_8	3						
SO4_16	3						
SO4_32	3						
SO4_H2O	3						
SO4_PO4	3						
CA_CL	3						
MG_CL	3						
K_CL	3						
NA_CL	3						
AL_CL	3						
CEC_CL	3						

Parameter	Possible Points	Points Awarded (Samples) 1	2	3	4	5	Total Score
CA_OAC	3						
MG_OAC	3						
K_OAC	3						
NA_OAC	3						
CEC_OAC	3						
CA_CL2	3						
MG_CL2	3						
K_CL2	3						
NA_CL2	3						
FE_CL2	3						
AL_CL2	3						
AC_BACL	3						
FE_PYP	3						
FE_AO	3						
FE_CD	3						
AL_PYP	3						
AL_AO	3						
AL_CD	3						
SI_AO	3						
SAND	3						
M_SAND	3						
SILT	3						
CLAY	3						
	Subtotals						

- Points are awarded per sample for being within accuracy windows or for meeting %RSD precision limits.

PART II. STANDARD RELATIONSHIPS

Parameter Group	Possible Points	Points Awarded (Samples)					Total Score
		1	2	3	4	5	
Soil pH	5						
Sulfate Isotherms	10						
Extractable Sulfate	5						
CEC	5						
article Size	5						
Subtotals							

- Points are awarded per sample.

PART III. QUALITY CONTROL

Sample Type	Possible Points[a]	Points Awarded (Samples)					Total Score
		1	2	3	4	5	
Reagent Blanks All < IDL One or more > IDL	 6 0						
QC Check Samples All QCCS within One or more QCCS out	 6 0						
Matrix Spikes All within 100 ± 10% recovery One or more out of criteria	 8 0						
Detection Limit QCCS All within 20% One or two outside 20% Three or more outside 20%	 30 15 0						
Instrument Detection Limits All IDLs < CRDL One IDL > CRDL Two or more IDLs > CRDL	 30 15 0						
Subtotals							

- Points are awarded per sample.

PART IV. REPORTING AND DELIVERABLES

Criteria	Possible Points	Points Awarded (Samples)					Total Score
		1	2	3	4	5	
Analytical data submitted in specified format	5						
QC data submitted in specified format	5						
Tabulated IDLs and associated blank data supplied	5						
Confirmation of summary results by signature of lab manager	5						
Subtotals							

- Points are awarded per sample.

ELEMENTAL ANALYSIS

PRE-AWARD PERFORMANCE EVALUATION SCORING SHEET

LABORATORY: ____________________

Quantitation: ____________________

Relationships: ____________________

Quality Control: ____________________

Deliverables: ____________________

TOTAL SCORE: ____________________

DATE: ____________________

Sample 1: ____________________

Sample 2: ____________________

Sample 3: ____________________

Sample 4: ____________________

Sample 5: ____________________

PERCENTAGE: ____________________%

(200 points possible per sample)

PART I. QUANTITATION

Parameter[a]	Possible Points[b]	Points Awarded (Samples) 1	2	3	4	5	Total Score
C_TOT	20						
N_TOT	20						
S_TOT	20						
	Subtotals						

[a] Refer to glossary for descriptions of parameters.

[b] Points are awarded per sample: two for being within accuracy windows and one for meeting %RSD precision limits; for certain summary parameters the values are three and two, respectively.

PART II. STANDARD RELATIONSHIPS

Parameter[a]	Possible Points[b]	Points Awarded (Samples) 1	2	3	4	5	Total Score
C_TOT/N_TOT	10						
C_TOT/S_TOT	10						
	Subtotals						

[a] Points are awarded per sample

PART III. QUALITY CONTROL

Parameter[a]	Possible Points[b]	Points Awarded (Samples)					Total Score
		1	2	3	4	5	
Reagent Blanks							
All < IDL	10						
One or more > IDL	0						
QC Check Samples							
All QCCS within	10						
One or more QCCS out	0						

Parameter[a]	Possible Points[b]	Points Awarded (Samples)					Total Score
		1	2	3	4	5	
Matrix Spikes							
All within 100 ± 10% recovery	20						
One or more out of criteria	0						
Detection Limit QCCS							
All within ± 20%	30						
Two or less outside ± 20%	15						
Three or more outside ±20%	0						
Instrument Detection Limits							
All IDLs within	30						
One IDL out	15						
Two or more IDLs out	0						
Subtotals							

---

[a] Points are awarded per sample.

PART IV. REPORTING AND DELIVERABLES

Criteria	Possible Points[a]	Points Awarded (Samples)					Total Score
		1	2	3	4	5	
Analytical data submitted in specified format	5						
QC data submitted in specified format	5						
Tabulated IDLs and associated blank data supplied	5						
Confirmation of summary results by signature of lab manager	5						
Subtotals							

---

[a] Points are awarded per sample.

Appendix F

Analytical Laboratory On-Site Evaluation Questionnaire

The following questionnaire is used by QA staff to provide documentation of on-site laboratory audits. An analytical laboratory is evaluated prior to the award of a contract to assess the ability of the laboratory, in terms of personnel, facilities, and equipment, to analyze soil samples successfully. A second evaluation is made after sample analysis is underway. At the time of the second evaluation, adherence to the Analytical Laboratory Statements of Work is evaluated and specific discrepancies are addressed.

ANALYTICAL LABORATORY ON-SITE EVALUATION QUESTIONNAIRE
DDRP SOIL SURVEY

GENERAL (Page 1 of 2)

Date: ______________________

Laboratory: ______________________

Street Address: ______________________

Mailing Address (if different from above): ______________________

____

City: ______________________

State: ______________________ Zip: ______________________

Laboratory Telephone Number: (   ) ______________________

Laboratory Director: ______________________

Laboratory Quality Assurance Officer: ______________________
(Quality Control Chemist)

Type of Evaluation: ______________________

Contract Number: ______________________

Contract Title: ______________________

GENERAL (Page 2 of 2)

Personnel Contacted:

Name	Title

Laboratory Evaluation Team:

Name	Title

ORGANIZATION AND PERSONNEL (Page 1 of 3)

LABORATORY ORGANIZATIONAL CHART

ORGANIZATION AND PERSONNEL (Page 2 of 3)

Laboratory Personnel

Position	Name	Academic Training*	Special Training	Years Experience**

*List highest degree obtained and specialty. Also list years toward a degree.
**List only experience directly relevant to task to be performed.

ORGANIZATION AND PERSONNEL (Page 3 of 3)

Item	Yes	No	Comment
Do personnel assigned to this project have the appropriate educational background to successfully accomplish the objectives of the program?			
Do personnel assigned to this project have the appropriate level and type of experience to successfully accomplish the objectives of this program?			
Is the organization adequately staffed to meet project commitments in a timely manner?			
Does the laboratory Quality Assurance Supervisor report to senior management levels?			
Was the Project Manager available during the evaluation?			
Were chemists and technicians available during the evaluation?			
Was the Quality Assurance Supervisor available during the evaluation?			

LABORATORY MANAGER (Page 1 of 1)

Item	Yes	No	Comment
Does the laboratory manager have his/her own copy of the standard operating procedures?			
Does the laboratory manager have his/her own copy of the instrument performance data?			
Does the laboratory manager have his/her own copy of the latest monthly QC plots?			
Is the laboratory manager aware of the most recent control limits?			
Does the laboratory manager review the following before reporting data:			
a. The data itself?			
b. The quality control data sheet with analyst notes?			
c. The general instrument performance and routine maintenance reports?			

STANDARD OPERATING PROCEDURES (SOP) (Page 1 of 1)

Item	Yes	No	Comment
Does the laboratory have a standard operating procedure (SOP) manual?			
Is the SOP manual followed in detail?			
Does the SOP manual contain quality control practices?			
Does each analyst/technician have a copy of the SOP manual?			
Does the SOP manual deviate from the procedures required by the project?			
If the SOP manual does deviate, are the deviations documented in written form?			
Does each analyst/technician have a copy of all methods and procedures required by this project?			
Are plots of instrumental accuracy and precision available for every analysis?			
Are detection limit data tabulated for each analysis?			

LABORATORY FACILITIES (Page 1 of 3)

When touring the facilities, give special attention to:
(1) the overall appearance of organization and neatness,
(2) the proper maintenance of facilities and instrumentation,
(3) the general adequacy of the facilities to accomplish the required work.

Item	Yes	No	Comment
Does the laboratory appear to have adequate workspace (6 linear meters of unencumbered bench space per analyst)?			
Does the laboratory have a source of distilled/demineralized water?			
Is the specific conductance of distilled/demineralized water routinely checked and recorded?			
Are the analytical balances located away from draft and areas subject to rapid temperature changes?			
Has the balance been calibrated within one year by a certified technician?			
Is the balance checked with a class S standard before each use and recorded in a logbook? Have technician demonstrate how this is done.			
Are exhaust hoods provided to allow efficient work with volatile materials?			
Have the hoods been checked for operating efficiency? How often is this done?			
Is the laboratory maintained in a clean and organized manner?			
Are contamination-free work areas provided for the handling of toxic materials?			
Are adequate facilities provided for separate storage of samples, extracts, and standards, including cold storage?			
Is the temperature of the cold storage units recorded daily in logbooks?			
Are chemical waste disposal policies/procedures adequate?			
Are contamination-free areas provided for trace level analytical work?			
Can the laboratory supervisor document that trace-free water is available for preparation of standards and blanks?			

LABORATORY FACILITIES (Page 2 of 3)

Item	Yes	No	Comment
Do adequate procedures exist for disposal of waste liquids from the ICP and AA spectrometers?			
Do adequate procedures exist for disposing of liquid and solid wastes?			
Is the laboratory secure?			
Are all chemicals dated on receipt and thrown away when shelf life is exceeded?			
Are all samples stored in the refrigerator between analyses?			
Are acids and bases stored in separate areas?			
Are hazardous, combustible, and toxic materials stored safely?			

LABORATORY FACILITIES

Item	Available		Comments (where applicable, cite system, QC check, adequacy of space)
	Yes	No	
Gas			
Lighting			
Compressed air			
Vacuum system			
Electrical services			
Hot and cold water			
Distilled water			
Laboratory sink			
Ventilation system			
Hood space			
Cabinet space			
Storage space(m^2)			
Refrigerated storage(4^oC)			

LABORATORY FACILITIES (page 3 of 3)

COMMENTS ON LABORATORY FACILITIES

EQUIPMENT GENERAL (Page 1 of 2)

Item	Equipment			Condition/age			Comments
	# of Units	Make	Model	Good	Fair	Poor	
Balance, analytical							
(1)							
(2)							
(3)							
Balance, top loader							
Class "S" weights							
Balance table							
NBS-calibrated thermometer							
Desiccator							
Distilled water							
Double deionized, distilled/deionized, or double distilled water							
Glassware							
(1) Beakers							
(2) Erlenmeyer flasks							
(3) Sedimentation cylinders							
(4) Graduated cylinders							
(5) Fleakers							
(6) Other							
Drying ovens							
Hot plates							
Water bath							
Centrifuge							
Vortex mixer							

EQUIPMENT GENERAL (Page 2 of 2)

Item	Equipment			Condition/age			Comments
	# of Units	Make	Model	Good	Fair	Poor	
Eppendorf pipets (or equivalent)							
Reciprocating shaker							

Comments:

MOISTURE CONTENT

Item	Manufacturer	Model	Installation Date	Comments
Balance, +0.01 g				
Convection ovens				

Item	Available	Quantity	Type	Comments
Thermometers 0 to 200°C				
Weighing containers				
Desiccator				
Desiccant				

Comments:

MOISTURE CONTENT (Page 2 of 2)

Question	Yes	No	NA	Comments
Is the balance calibrated weekly?				
Do thermometers have a range of -20 to 200°C?				
Are thermometers calibrated (with barometric correction) at the boiling and freezing points at least once every 3 months?				
Is the oven temperature checked and recorded daily?				
Is the oven temperature calibrated at least monthly?				
Are organic soil samples dried at the specified temperature?				
Are replicates of each sample prepared and run?				
Are mineral soil samples dried at the specified temperature?				
Are two separately calibrated ovens used, one for organic and one for mineral soils?				
If only one oven is used, is at least 24 hours allowed for the oven to stabilize at the new temperature?				
Is sample-drying time extended as specified in the procedure?				
Are calculations correctly performed, and are at least 5% (or 2 per batch) checked by hand?				

PARTICLE SIZE ANALYSIS

Item	Manufacturer	Model	Installation Date	Comments
Hot plate or block digester				
Analytical balance, 0.1mg				
Shaker horizontal reciprocating (120 oscillations/min)				
Sieve shaker (1.25 cm vertical and lateral movement)				
Complete sieve set with receiving pan				
Automatic pipets				
Shaw pipet rack				
Motor-driven stirrer				

PARTICLE SIZE ANALYSIS

Item	Available	Quantity	Type	Comments
Thermometer 10 to 50°C				
Erlenmeyer flask or Fleaker 300 mL				
Pasteur-Chamberlain filter candles (fineness"F")				
1-L Sedimentation cylinders				
Insulation covering				
Hand-driven stirrer				

PARTICLE SIZE ANALYSIS (Page 2 of 4)

Item	Available	Quantity	Type	Comments
Shaw pipet rack equivalent				
Ring stand				
Clamp				
Volumetric pipet, 25 mL				
Evaporating dishes				
Waterproof markers or paint pens				
Weighing bottles, 90-mL wide-mouth				
Desiccator				

Set of sieves, square-mesh, woven phosphor-bronze or stainless steel wire cloth; U.S. Series and Tyler Screen Scale equivalent designations as follows:

Nominal Opening(mm)	U.S. No.	Tyler Mesh Size
1.0	18	16
0.5	35	32
0.25	60	60
0.105	140	150
0.046	300	300

PARTICLE SIZE ANALYSIS

Chemical	Quantity	Grade	Expiration Date	Comments
Hydrogen peroxide (H_2O_2) 30 to 35%				
Dessicant: Phosphorus pentoxide (P_2O_5)				
Sodium carbonate (Na_2CO_3)				
Sodium Hexametaphosphate $(NaPO_3)_6$				

PARTICLE SIZE ANALYSIS (Page 3 of 4)

Comments:

PARTICLE SIZE ANALYSIS

Question	Yes	No	NA	Comments
Is analysis performed on mineral horizons only?				
Is the organic matter removed as specified before proceeding?				
Are chemicals reagent grade or better?				
Is heat applied after organic matter is visibly destroyed to remove excess H_2O_2?				
Is reciprocating shaker calibrated once every 6 months if no gauge is included (every year with gauge)?				
Is the 500 stroke per minute (1.25 cm vertical and lateral oscillator) shaker calibrated once every 6 months?				
Are pipets calibrated monthly, gravimetrically on a calibrated balance?				

PARTICLE SIZE ANALYSIS (Page 4 of 4)

Question	Yes	No	NA	Comments
Are the specified methods used for separating sand, silt, and clay?				
Is a standard sand, silt, clay "soil" used as a control?				
Is the water temperature checked during sedimentation to determine when to take a sample?				
Are the specified procedures followed during sedimentation?				
Is note made of which sedimentation table is used to determine sampling depth and time?				
Are weights for each mineral fraction correctly recorded and calculated?				
Are calculations correctly performed, and				
are at least 5% (or 2 per batch) checked by hand?				

pH DETERMINATION

Item	Manufacturer	Model	Installation Date	Comments
Digital pH meter				
Combination electrodes, non-gel type				

Item	Available	Quantity	Type	Comments
Thermometer				
Beakers, 50 mL				
Stirrers				
QCCS standard				

Chemical	Quantity	Grade	Expiration Date	Comments
Calcium Chloride($CaCl_2$)				
Calcium hydroxide ($Ca(OH)_2$)				
Chloroform ($CHCl_3$) or Thymol($C_{10}H_{14}O$)				
Hydrochloric acid (HCl)				
National Bureau of Standards (NBS) buffers				
Potassium Biphthalate ($KHC_8H_4O_4$)				
Potassium chloride (KCl)				

pH DETERMINATION (Page 2 of 3)

Question	Yes	No	NA	Comments
Are chemicals reagent grade or better?				
Is the air-dried soil stored in sealed containers?				
Is the pH meter digital to +0.01 (and +1 mv)?				
Does the pH meter have internal temperature compensation to +0.5°C?				
Is the combination electrode a non-gel type?				
Is the combination electrode of the recommended style with retractable sleeve junction?				
Are the buffers calibrated daily to +.01 pH units?				
Is the pH meter: - calibrated before samples are analyzed -checked every batch as stated in methods				
Is temperature compensation manual or internal?				
Are equilibrium times required for standards checked, to see if electrode response is slowing?				
Is a spare combination electrode available and properly stored?				
Is manufacturer recommended warm-up time allowed before samples are run?				
Are pH meters placed away from drafts and areas of rapid temperature change?				
Are the specified between-sample procedures followed?				
Are pH units equipped with programmable sampling times?				
If yes above, are they used in this analysis?				
Are electrodes properly stored and maintained?				
Are the QC results plotted in real time?				

pH DETERMINATION (Page 3 of 3)

Question	Yes	No	NA	Comments
What is the QCCS sample?				
Is the QCCS solution analyzed first and thereafter as called for in the methods?				
Are a QCCS and duplicate sample included in each run?				
Is the quality control data reviewed by the analyst before deciding whether to release the data for reporting?				

CATION EXCHANGE CAPACITY

Item	Manufacturer	Model	Installation Date	Comments
Mechanical extractor				
Flow injection analyzer				
Titration apparatus				
Reciprocating shaker				

Item	Available	Quantity	Type	Comments
Steam distillation unit				
Digestion tubes 250 mL				
Kjeldahl flasks, 800 mL				
Analytical filter pulp				
Disposable syringes 60 mL				
Rubber tubing connectors				
Linear polyethylene bottles, 25 mL				

CATION EXCHANGE CAPACITY

Chemical	Quantity	Grade	Expiration Date	Comments
Glacial acid (HC2H3O2)				
Ammonium hydroxide (NH4OH)				
Ammonium acetate (NH4OAC)				
Ammonium chloride				

CATION EXCHANGE CAPACITY (Page 2 of 5)

Chemical	Quantity	Grade	Expiration Date	Comments
(NH4Cl)				
Ethanol (CH3CH2O), 95%				
Nessler's reagent				
Potassium iodide (KI)				
Mercuric iodide (HgI2)				
Sodium hydroxide (NaOH)				
Sodium chloride (NaCl)				
Antifoam				
Hydrochloric acid (HCl)				
Sodium carbonate (Na2CO3				
Methyl orange indicator				
Boric Acid				
Zinc, granular				
Phenol (C6H6O)				
Potassium sodium tartrate				
(KNaC4H4O6). 4H2O				
Sodium citrate (Na3C6H5O7). 2H2O)				
Sodium nitro-ferricyanide (Na3Fe(CN)5 NO3.2H2O				

CATION EXCHANGE CAPACITY (Page 3 of 5)

Chemical	Quantity	Grade	Expiration Date	Comments
Sodium hypochlorite (NaOCl)				

Comments:

CATION EXCHANGE CAPACITY (Page 4 of 5)

Question	Yes	No	NA	Comments
Are the chemicals reagent grade or better?				
Are dilute standards prepared and calibrated daily?				
Are working standards prepared and calibrated at least weekly?				
Are reagents stored properly to prevent premature decomposition?				
Are hazardous chemicals used strictly under the hood?				
Is an antifoam agent available for use?				
Is all glassware cleaned and stored as specified?				
Does the flow injection analyzer (FIA) have the correct interference filter?				
Are the pump lines inspected for wear before each run?				
Is the heat bath of the FIA calibrated monthly and checked before each run?				
Are the pump tubes all of the correct type for there agents and method in use?				
Are all peripherals such as printer, plotter, and disk drives functional and, in the case of recorders and plotters, calibrated before each run?				
Is the shaker used for organic samples calibrated every six months or less along with general maintenance?				
Is the auto analyzer (distillation/ titration) calibrated for titration before each run?				
Are the condensation facilities of the distillation apparatus inspected before each run?				
Are all calculations performed correctly, and are at least 5% being checked by hand?				
Is the mechanical extractor calibrated for extraction time?				
Is the calibration of the mechanical extractor checked at least monthly?				

CATION EXCHANGE CAPACITY (Page 5 of 5)

Question	Yes	No	NA	Comments
Are the specified size, type, and grade of disposable syringes used with the extractor?				
Is the tubing checked frequently and replaced when needed?				
Is the filter pulp washed before the extraction is performed?				
Are all procedures involving the extraction followed precisely according to the statement of work?				
Are three blanks carried through to record mean and standard deviation?				

EXCHANGEABLE CATIONS

Item	Manufacturer	Model/Grade	Installation Date	Comments
Flame atomic absorption spectrometer				
Inductively coupled plasma emission spectrometer				
Atomic flame emission spectrometer				

Chemical	Quantity	Grade	Expiration Date	Comments
Argon				
Acetylene gas (C_2H_4)				
Natural gas (CH_4)				
Hydrochloric acid (HCl)				
Nitric acid (HNO_3)				
Calcium carbonate ($CaCO_3$)				
Magnesium oxide (MgO)				
Potassium chloride (KCl)				
Sodium chloride($NaCl$)				
Lanthanum oxide (La_2O_3)				
Cesium chloride ($CsCl$)				

EXCHANGEABLE CATIONS (Page 2 of 3)

Chemical	Quantity	Grade	Expiration Date	Comments
Lithium chloride (Licl)				
Lithium nitrate (LiNO3)				
QCCS				
Calcium (Ca)				
Magnesium (Mg)				
Potassium (K)				
Sodium (Na)				
Aluminum (Al)				

Comments:

EXCHANGEABLE CATIONS (Page 3 of 3)

Question	Yes	No	NA	Comments
Is the analytical instrument cleaned and adjusted before and after each run?				
Is the power source secure, that is, protected against line fluctuation?				
Are standards made in a matrix as close as possible to that of the extract?				
If the lanthanum oxide method is used, is the La2O3 added to the samples and standards?				
Are the pHs of the samples and standards approximately identical?				
Are all chemicals of analytical reagent grade or better?				
Are chemicals used for standards traceable to NBS standards?				
Does the laboratory have copies of Methods for Chemical Analysis of Water and Wastes, and Standard Methods 14th edition or access to them?				
Are all calculations performed correctly, and are at least 5% (2 per batch) checked manually?				

LIME AND ALUMINUM POTENTIAL

Item	Manufacturer	Model/Grade	Installation Date	Comments
Flame atomic absorption spectrometer				
Inductively coupled plasma spectrometer				
Flame atomic emission spectrometer				

Item	Available	Quantity	Type	Comments
Reciprocating shaker				
Linear polyethylene bottles (25 and 50mL)				
250 mL polypropylene centrifuge bottles				

Chemical	Quantity	Grade	Expiration Date	Comments
Calcium chloride ($CaCl_2$)				
Hydrochloric acid(HCl)				
NBS traceable standards:				
Calcium (Ca)				
Magnesium (Mg)				
Potassium (K)				
Sodium (Na)				
Iron (Fe)				
Aluminum (Al)				

LIME AND ALUMINUM POTENTIAL (Page 2 of 2)

Comments:

LIME AND ALUMINUM POTENTIAL

Question	Yes	No	NA	Comments
Is the reciprocating shaker calibrated every six months or less in addition to general maintenance?				
What is the QC sample?				
Is the QC solution analyzed initially as called for in the methods?				
Are the QC results plotted on QC charts in real time?				
Is the quality control data reviewed by the analyst before deciding whether to release the data for reporting?				
Are the results for Ca reported after adjusting for the CaCl2 extraction solution?				
Are results reported based on oven-dry soil weight?				
Are all calculations correctly performed, and are 5% (2 per batch) checked manually?				

EXTRACTABLE IRON AND ALUMINUM

Sodium Pyrophosphate, Citrate Dithionite and Acid Oxalate Methods

Item	Manufacturer	Model	Installation Date	Comments
Centrifuge				
Inductively coupled plasma spectrometer				

Item	Available	Quantity	Type	Comments
Reciprocating shaker				
Repipet				
Automatic pipet				
Buret				
250 mL polypropylene centrifuge bottles				
Fleakers				
Volumetric pipets				
Volumetric flasks				

EXTRACTABLE IRON AND ALUMINUM

Chemicals	Quantity	Grade	Expiration Date	Comments
Sodium pyrophosphate				
Sodium hyroxide (Na OH)				
pH buffers, pH=7 and 10				
Phosphoric acid(H_3PO_4)				
Superfloc 16				
Sodium dithionite ($Na_2S_2O_4$)				

EXTRACTABLE IRON AND ALUMINUM (Page 2 of 3)

Chemicals	Quantity	Grade	Expiration Date	Comments
Sodium citrate ($Na_3C_6H_5O_7\ H_2O$)				
Ammonium oxalate ($(NH_4)_2C_2O_4.H_2O$)				
Oxalic acid ($H_2C_2O_4.H_2O$)				
pH buffers, pH = 4 and 2				
Nitric acid (HNO_3)				

Comments:

EXTRACTABLE IRON AND ALUMINUM (Page 3 of 3)

Question	Yes	No	NA	Comments
Are the proper type of polypropylene 250 mL centrifuge tubes used?				
Is the reciprocating shaker calibrated yearly if it possesses a speed gauge, every 6 months if not?				
Is the centrifuge calibrated yearly if it possesses a speed gauge, every 6 months if not?				
Are standards made up in the same expected matrix as are the extracts?				
Are the chemicals reagent grade or better?				
Is the extract promptly stored at 4°C?				
Is analysis performed for Fe and Al within 24 hours of extraction?				
Are the calculations carried out correctly and are at least 5% (2/batch) checked by hand?				

EXTRACTABLE SULFATE

Item	Manufacturer	Model	Installation Date	Comments
Balance, +0.01 g				
Ion chromatograph				
Automated injection system				
Filtration apparatus				
Centrifuge				
Vortex mixture				
Reciprocating shaker				

Item	Available	Quantity	Type	Comments
100-mL centrifuge tubes with screw caps				
Volumetric flasks				
0.20 m pore size membrane filters				
Volumetric pipets				

Chemical	Quantity	Grade	Expiration Date	Comments
Monobasic sodium phosphate (NaH2PO4.H2O)				
Sodium carbonate (Na2CO3)				
Sodium hydroxide (NaOH)				

EXTRACTABLE SULFATE (Page 2 of 3)

Chemical	Quantity	Grade	Expiration Date	Comments
Sulfuric acid (H_2SO_4)				
Magnesium sulfate (Mg_2SO_4)				
Sodium nitrate ($NaNO_3$)				

Question	Yes	No	NA	Comments
Is the ion chromatograph maintained according to manufacturer's specifications?				
Are manufacturer recommendations for optimum IC sensitivity used?				
Are chemicals reagent grade or better?				
Are the phosphate and sulfate concentration low enough so they elute separately? Are dilutions made if not?				
Are all the proper accessories maintained on the IC? -anion separation column? -micro-membrane suppressor (anion separation) column?				
Is the optional automatic injection system used?				
Are all solutions made fresh when needed? -0.40 M $NaCO_3$ -0.0020 M Na_2CO_3 / 0.0020 M NaOH -other -stock resolution standard -working resolution standard -sulfate and nitrate calibration				
Are conversion operations performed correctly for: -meq/L to mg/L SO_4? (1 meq = 48.0288 mg) -mg/L to meq/L SO_4? (1 meq = 0.02082 meq) -SO_4 to S? (1 mg SO_4 = 0.3338 mg S) -S to SO_4? (1 mg S = 2.9962 mg SO_4)				
Are recording instruments calibrated before each use?				

EXTRACTABLE SULFATE (Page 3 of 3)

Question	Yes	No	NA	Comments
Is a pump stroke noise suppressor or pressure gauge used to stabilize pressure?				
Is resolution high enough so no startover is required?				
Are peak heights/areas recorded in a logbook?				
If peaks are not sharp and symmetric, is an approved method for peak area determination used?				
Is peak area determined by microprocessor? If yes, which methods and formulas does it use?				
Are calibration curves constructed according to manufacturer's recommendations?				
Is the flow rate checked gravimetrically with time for consistency of flow?				
Is the rate of flow calibrated before each batch is run?				

SULFATE ADSORPTION ISOTHERMS

Item	Manufacturer	Model	Installation Date	Comments
Balance, +0.01g				
Ion chromatograph				
Centrifuge				
Filtration apparatus				
Reciprocating shaker				

Item	Available	Quantity	Type	Comments
Centrifuge tubes with screw caps, 100 or 50mL				
0.45 um pore size membrane filters				
Volumetric pipet, 50 mL				

Chemical	Quantity	Grade	Expiration Date	Comments
Magnesium sulfate (MgSO4)				

Comments

____
____
____
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____
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SULFATE ADSORPTION ISOTHERMS (Page 2 of 2)

Question	Yes	No	NA	Comments
Are MgSO4 adsorption solutions correctly prepared?				
Are the adsorption solutions calibrated for accuracy before being used in the run?				
Are the working standards made fresh daily?				
Is the deionized water sent through the 0.20 um membrane filter?				
Is the supernatant sent through the 0.45 um membrane filter?				
Is the correct amount of soil (oven-dried weight) used?				
Are methods of analysis by ion chromatography the same as used in the extractable sulfate procedure?				
Are the correct conversion factors used as in the extractable sulfate procedure?				
Are all calculations performed correctly, and are at least 5% (2 per batch) checked?				

EXCHANGEABLE ACIDITY

Item	Manufacturer	Model	Installation Date	Comments
Mechanical extractor				
Reciprocating shaker				
Automatic titrator				
pH meter				
pH electrode				

Item	Available	Quantity	Type	Comments
Syringes 60mL				
Filter pulp				
Pipettors, adjustable to 25 mL				
Stirring rods				
Titration (Erlenmeyer) 250 and 125 mL				
Tubes, 25 mL glass				
Eppendorf pipets, 5 mL and 5L				
Diluter				
Volumetric flasks				
Linear polyethylene bottles 25 mL				
Drying tube				

EXCHANGEABLE ACIDITY (Page 2 of 4)

Chemical	Quantity	Grade	Expiration Date	Comments
Ascarite				
Barium chloride (BaCl2.2H2O)				
Triethanolamine (N(CH2CH2OH)3)				
Hydrochloric acid (HCl)				
Sodium hydroxide (NaOH)				
Methyl orange indicator				
NBS-traceable buffers, pH=4, 7, and 10				

Comments:

EXCHANGEABLE ACIDITY (Page 3 of 4)

Question	Yes	No	NA	Comments
Is the buffer solution protected from CO2?				
Are the syringes prepared according to protocol?				
Is the pH calibration the same as for the pH procedure (comment on any exceptions)?				
Is the automatic titrator calibrated gravimetrically before each batch?				
Is the pH endpoint of the automatic titrator calibrated to 4.60?				
Are at least 5% of the calculations checked manually?				
Are calculations performed correctly?				
Is the reciprocating shaker calibrated every six months or less in addition to general maintenance?				
Is the auto analyzer (distillation/ titration) calibrated for titration before each run?				
Are titration results calculated, and are 5% hand checked?				
Is the 25-mL pipetter calibrated gravimetrically daily (if the adjustable type) and at least weekly if a fixed volume?				
Is the diluter calibrated and checked gravimetrically before each run?				
Is the same amount of filter pulp used with each sample?				
Is the filter pulp washed before use?				
Is the specified number of blanks run for each batch?				
Are chemicals of reagent grade or better?				
Is the mechanical extractor calibrated for extraction time?				
Is the calibration of the mechanical extractor checked at least monthly?				
Are the specified size, type, and grade of disposable syringes used with the extractor?				

EXCHANGEABLE ACIDITY (Page 4 of 4)

Question	Yes	No	NA	Comments
Is the tubing checked frequently and replaced when needed?				
Are all procedures involving the extraction followed precisely according to the statement of work?				
Are three blanks carried through to record mean and standard deviation?				

FLAME ATOMIC ABSORPTION SPECTROSCOPY

Question	Yes	No	NA	Comments
For which methods is this instrument used?				
Is the burner head cleaned and adjusted for each run?				
Is the burner head cleaned frequently when solutions of high ionic strength are analyzed?				
Is DI water or cleaning solution aspirated both before and after a run?				
Is the nebulizer cleaned at least weekly?				
Is the correct flame type used for determination of each element?				
Is the acetylene of specified purity?				
Is gas pressure monitored during a run?				
Are filters used to remove water and oil from the compressed air?				
Is constant air pressure maintained? How?				
Is the wavelength optimized before a run?				
Is the slit width correctly set for the desired element?				
Is the optical system aligned at least every 6 months? With a major realignment every 12 months?				
Are the lamp and instrument allowed adequate time to warm up before use -Lamp time (30-60+ minutes)? -Instrument time (constant if possible)? -Flame time (5+ minutes)?				
Is the unit adequately vented?				
Is tubing inspected before each run?				

INDUCTIVELY COUPLED PLASMA EMISSION SPECTROSCOPY

Question	Yes	No	NA	Comments
For which methods is this instrument used?				
Is the tubing inspected before each run?				
Are the electrodes replaced as instructed by the manufacturer or more frequently?				
Is the instrument adequately vented?				
Is the instrument in a temperature controlled room?				
Is ample time allowed for the instrument to warm up?				
Are standards calibrated both alone and as part of a multi-element matrix?				
Is the UV-IR shielding in place?				
Is an adequate supply of the carrier gas present?				
Are manufacturer operating procedures followed?				
On multi-element units, are alternate wavelengths used when necessary to avoid interference?				

FLAME PHOTOMETRY (FLAME ATOMIC EMISSION)

Question	Yes	No	NA	Comments
For which methods is this instrument used?				
Are the correct filters used for each element?				
Is the pressure of the gases monitored during a run?				
Is the oxygen supply of 99.95% purity or higher?				
Is the fuel supply of sufficient purity and of constant pressure?				
Is the aspirator cleaned before and after each run?				
Is a rinse solution of DI water (or wash solution) used between samples to prevent salting-up of the aspirator?				
Is the unit given adequate time to warm up before use?				
Is the unit calibrated before use?				
Is the aspirator/nebulizer unit inspected daily for proper seating and function?				
Is the unit placed away from areas of drafts and sudden temperature changes?				

DOCUMENTATION/TRACKING

Item	Yes	No	Comment
Is a sample custodian designated? If yes, name of sample custodian ________________.			
Are the sample custodian's procedures and responsibilities documented? If yes, where are these documented?			
Is sample tracking performed via paper or computer?			
Are written standard operating procedures (SOP) developed for receipt of samples? If yes, where are they documented?			
Are written standard operating procedures (SOP) developed for compiling and maintaining sample document files? If yes, where are they documented?			
Are samples stored under refrigeration? At what temperature?			
After completion of the analysis are the samples properly stored for six months or until laboratory personnel are told otherwise?			

ANALYTICAL METHODOLOGY

Item	Yes	No	Comment
Are the required methods used?			
Is there any unauthorized deviation from contract methodology?			
Are written analytical procedures provided to the analyst?			
Are reagent grade or higher purity chemicals used to prepare standards?			
Are fresh analytical standards prepared at a frequency consistent with good QA?			
Are reference materials properly labeled with concentrations, date of preparations, and the identity of the person preparing the sample?			
Is a standard preparation and tracking logbook maintained?			
Do the analysts record bench data in a neat and accurate manner?			
Is the appropriate instrumentation used in accordance with the required protocol(s)?			

ANALYTICAL METHODOLOGY (Page 2 of 2)

COMMENTS ON ANALYTICAL METHODS AND PRACTICES

QUALITY CONTROL

Item	Yes	No	Comment
Does the laboratory maintain a quality control manual?			
Does the manual address the important elements of a QC program, including the following:			
a. Personnel?			
b. Facilities and equipment?			
c. Operation of instruments?			
d. Documentation of procedures?			
e. Procurement and inventory practices?			
f. Preventive maintenance?			
g. Reliability of data?			
h. Data validation?			
i. Feed back and corrective action?			
j. Instrument calibration?			
k. Record keeping?			
l. Internal audits?			
Are QC responsibilities and reporting relationships clearly defined?			
Have standard curves been adequately documented?			
Are laboratory standards traceable?			
Are quality control charts maintained for each routine analysis?			
Do QC records show corrective action when analytical results fail to meet QC criteria?			
Do supervisory personnel review the data and QC results?			
Does the QC chemist have a copy of the standard operating procedures?			
Does the QC chemist have a copy of the instrument performance data?			
Does the QC chemist have a copy of the latest QC plots?			

QUALITY CONTROL (Page 2 of 2)

Item	Yes	No	Comment
Is the QC chemist aware of the most recent control limits?			
Does the QC chemist prepare a blind audit sample once per week?			
Does the QC chemist routinely review and report blank audit data to the laboratory manager?			
Does the QC chemist update control limits and obtain new control charts once per batch?			
Are all QC data (e.g., control charts, regression charts, QC data bases) up to date and accessible?			
Are minimum detection limits calculated as specified?			
Is QC data sheet information reported to the analyst?			

DATA HANDLING (Page 1 of 2)

Item	Yes	No	Comment
Does data clerk check all input to the computer for accuracy?			
Are calculations checked by another person?			
Are calculations documented?			
Does strip chart reduction by on-line electronic digitization receive at least 5% manual spot checking?			
Are data from manually interpreted strip charts spot-checked after initial entry?			
Do laboratory records include the following:			
-Sample identification number			
-Sample type			
-Date sample received in laboratory			
-Date of analysis			
-Analyst			
-Result of analysis (including raw analytical data)			
-Recipient of the analytical data			
Does laboratory follow required sample tracking procedures from sample receipt to discard?			
Does the data clerk routinely report quality control data sheet information to the analyst?			
Does the data clerk submit quality control data sheet information to the laboratory manager, along with the analytical data to be reported?			
Do records indicate corrective action taken?			
Are provisions made for data storage for all raw data, calculations, quality control data, and reports?			
Are all data and records retained the required amount of time?			
Are computer printouts and reports routinely spot-checked against laboratory records before data are released?			

SUMMARY (Page 1 of 2)

Item	Yes	No	Comment
Do responses to the evaluation indicate that project and supervisory personnel are aware of QA and its application to the project?			
Do project and supervisory personnel place positive emphasis on QA/QC?			
Have responses with respect to QA/QC aspects of the project been open and direct?			
Has a cooperative attitude been displayed by all project and supervisory personnel?			
Does the organization place the proper emphasis on quality assurance?			
Have any QA/QC deficiencies been discussed before leaving?			
Is the overall quality assurance adequate to accomplish the objectives of the project?			
Have corrective actions recommended during previous evaluations been implemented?			
Are any corrective actions required? If so, list the necessary actions below.			

SUMMARY (Page 2 of 2)

Summary Comments and Corrective Actions

Appendix G

Field Data Verification Procedures

The following verification scheme represents the checks and flags that are applied to the pedon characterization data. After a pedon description undergoes verification, flagged data are identified on forms and are sent to the appropriate sampling crews for confirmation or correction. The corrections are edited into the data base and the verification program is applied to the data base to assign the final verification flags.

SCS-SOI-232 FIELD DATA VERIFICATION PROCEDURES (10/19/88)

MID-APPALACHIAN SOIL SURVEY

These procedures are strictly related to computer verification programs. Other verification procedures are discussed in the QA Plan. Parameters that may be left blank will be denoted by a '*' symbol. All other parameters should be filled in; if not, they are flagged.

The first test of each parameter is usually to determine whether the value in that parameter is missing. In SAS, a non-numeric character can not be placed in a parameter that has been identified for numeric values and will therefore be considered a missing . If a value for a parameter is considered missing and flagged A0, the other tests on the particular parameter will not be run.

The field data flag codes are as follows:

FLAG	FLAG DESCRIPTION
A0	value missing
B0	invalid code
C0	non-numeric character in numeric field
D0	non-alphabetic character in alpha field
E0	correlation outlier
F0	value inappropriate

NAME - can be left alone

SITE ID

ERL-C will provide a list of the valid STATE/COUNTY/UNIT combinations for each pedon. This combination will be called SITE_ID. If the combination on the 232 does not match an ERL-C combination or the combination has already been used flag, flag SITE_ID B0

STATE (SA_ST) alpha
If SA_ST code is missing, flag A0
If SA_ST not equal to PA, VA, WV, flag B0
If SA_ST code contains a numeral, flag D0

COUNTY (SA_CO) - numeric
If SA_CO code missing, flag A0
If SA_CO code contains alpha character, flag C0

UNIT (SA_UN) - numeric
If SA_UN code missing, flag A0
If SA_UN code contains alpha character, flag C0

* sub (SUB_UNS) - Leave alone

MLRA

MLRA and SUBMLRA must be linked. MLRA may or may not contain SUBMLRA. MLRA and SUBMLRA must also be correlated with the STATE codes

MLRA - numeric

If MLRA code missing, flag A0
* SUB (MLRA_S) - alpha (see MLRA)
If MLRA_S contains numeric characters, flag D0

The following are MLRA & MLRA_S codes that apply to each STATE:

PA	VA	WV
127	128	127
140	130	128
147	147	
	148	

If MLRA is not a valid code for the STATE, flag B0

LATITUDE

LAT - numeric
If LAT code is missing, flag A0

LAT_DR - alpha
If LAT_DR is missing, flag A0
If LAT_DR does not equal to "N", flag B0
If LAT_DR contains numeric characters, flag D0

LONGITUDE

LNG - numeric - Same flags as LAT
LNG_DR - alpha
If LNG_DR code missing, flag A0
If LNG_DR code does not equal to "W", flag B0
If LNG_DR contains numeric characters, flag D0

SLOPE

SL_PCT - numeric
If SL_PCT code is missing, flag A0
If SL_PCT contains alpha characters, flag C0

SL_SHPU/SL_SHPA - numeric
If SL_SHP code is missing, flag A0
If SL_SHP does not equal to a number from 1-5, flag B0

SL_GMP - numeric (see gm codes for values)
If SL_GMP code is missing, flag A0
If SL_GMP does not equal to 1,2,3,4, flag B0

SL_HILL - numeric
If SL_HILL code is missing, flag A0
If SL-HILL does not equal 1,2,3,4,5 flag B0

SL_ASP - numeric
If SL_ASP code is missing and PED_O does not equal H, flag A0
If PED_O does not equal H, then SL_ASP must equal 0, 45, 90, 135, 180, 225, 270, 315 if not flag B0
If PED_O equals H, then SL_ASP can be blank
SL_LEA - numeric
If SL_LEA code missing, flag A0
If SL_LEA contains alpha characters, flag C0

SL_LET - numeric
If SL_LET code missing, flag A0
If SL_LET < SL_LEA, flag EO
IF SL_LET contains alpha characters, flag C0

SL_KND - alpha
If SL_KND code is missing, flag A0
If SL_KND does not equal B,C,F,G,L,M,T,Z, flag B0
If SL_KND contains numeric characters, flag D0

SL_VAR - numeric
If SL_VAR code is missing, flag A0
If SL_VAR does not equal a number from 0,1,2,4, flag B0

SL_PAT - numeric
If SL_PAT code is missing, flag A0
If SL_PAT does not equal a number from 0-3, flag B0

SL_POS - numeric
If SL_POS code is missing, flag A0
If SL_POS does not equal a number from 2,3,4,5,7,8,9, flag B0
If SL_POS contains an alpha character, flag C0

PG_REG - alpha (major landform for codes)
If PG_REG code is missing, flag A0
If PG_REG does not equal a specified code, flag B0

PG_LOC - alpha (see local landform for codes)
If PG_LOC code is missing, flag A0
If PG_LOC does not equal a specified code, flag B0
If PG_LOC contains a numeric character, flag D0

PEDON CLASSIFICATION

This values will be hand checked against soil series name

* Precip (PREC) - leave alone

WATER TABLE

*WT_DPT - numeric.
If WT_KND is zero, WT_DPT should be blank; if not, flag B0
If WT_KND is not zero and WT_DPT is missing, flag A0

WT_KND - numeric
If WT_KND does not equal a number 0,2,3,4, flag B0
If WT_KND is missing, flag A0
If WT_KND contains alpha characters, flag C0

WT_DAY - numeric
IF WT_KND filled in, WT_DAY should have code; if not, flag A0
IF WT_KND not equal to a number between 1-365, flag F0

LU_CLS - alpha
If LU_CLS code is missing, flag A0
If LU_CLS does not equal A,C,E,F,G,H,I,J,L,N,O,P,R,S,T,U,Q, flag B0
If LU_CLS contains a numeric character, flag D0

SN_CLS - numeric
If SN_CLS code is missing, flag A0
If SN_CLS does not equal a number from 0-5, flag B0

If SN_CLS contains an alpha character, flag C0

BA_PRM - numeric
If BA_PRM code is missing, flag A0
If BA_PRM does not equal a number from 1-7, flag B0
If BA_PRM contains an alpha character, flag C0

Texture classes from coarse to fine are listed below. Scan TT_CLS1 and TT_CLS2, find which code on the 232 is the lowest on the list. The numbers to the right should be the corresponding PERM code, if not, flag PERM with E0

TT_CLS	PERM
COS	6-7
S	
FS	
VFS	
LCOS	
LS	

LFS	3-5
LVFS	
COSL	
SL	
FSL	
VFSL	
L	
SIL	
SI	
CSCL	
SCL	
CL	
SICL	
SC	
SIC	1-2
C	

DR_CLS (numeric)
If DR_CLS code is missing, flag A0
If DR_CLS does not equal a number from 1-7, flag B0
If DR_CLS contains an alpha character, flag C0
If SL_PCT > 15 and PERM = 1-4; DR_CLS should = 1-5; else flag E0
If SL_PCT > 15 and PERM = 5-7; DR_CLS should = 4-7; else flag E0

Elevation (ELEV) - numeric information should be right justified
with leading zeros on the left.
If ELEV code is missing, flag A0

PARENT MATERIAL

For this category only 1 entry for the parameters PM_WTH1, PM_DEP1, PM_B1, PM_ORG1 is needed.

PM_B1 (2,3,4) - numeric
If PM_B1 code is missing, flag A0
If PM_B1 does not equal 1,2,3, flag B0

PM_DEP1 (2,3,4) - alpha
If PM_DEP1 (2,3,4) code is missing, flag A0
If PM_DEP1 does not equal A,S,L,V,R,E,D,M,U,H,G,O,X,W,T,Y,F, flag B0
If PM_DEP1 contains a numeric character, flag D0

PM_ORG1 (2,3,4) alpha in first column, numeric in second
If PM_ORG1 code is missing, flag A0
PM_ORG1 If 1st column is not alpha, flag D0
If 2nd column is not numeric, flag C0

* PM_BRK - numeric

If PM_BRK does not equal a number from 1-5, flag B0
If PM_BRK contains an alpha character, flag C0

TEMPERATURES

All parameters can be left alone

MOISTURE REGIME

MREG - alpha
If MREG code is missing, flag A0
If MREG does not equal UD or AQ, flag B0
If MREG contains numeric values, flag D0

WEATHER STATION NUMBER

Can be left alone

CONTROL SECTION

CS_DPU - numeric
If CS_DPU value is missing, flag A0
If CS_DPU not less than CS_DPL, flag E0

CS_DPL - numeric
If CS_DPL value is missing, flag A0

If control section data is missing the following correlation will not be executed

CS_DPU & CS_DPL are checked together for the following conditions:

Control section rules for MASS when TT_ORD other than H, or when HZ_MST not = B and HZ_SFX not = T, or when HZ_SFX, HZ_MST not = R

1) If depth (HZ_DPL from page 2) of last horizon above any horizon where HZ_MST="R" is greater than 100; CS_DPU = 025 and CS_DPL = 100

2) If HZ_DPL of last above any horizon where HZ_MST="R" is greater than 36 and less than 100; CS_DPU = 025 and CS_DPL = HZ_DPL of last horizon above horizon where HZ_MST = "R"

3) If HZ_DPL of last horizon above any horizon where HZ_MST="R" is less than 36; CS_DPU = 000 and CS_DPL = HZ_DPL of last horizon horizon where HZ_MST = "R"

If rule is not followed, flag E0 where problem occurs

If HZ_MST or TX_ORD is H then:

1) If HZ_DPL of last horizon with a HZ_MST of O is greater than 130 CS_DPU = 000 and CS_DPL = 130

2) If HZ_DPL of last horizon with a HZ_MST of O is less than 130 CS_DPU = 000 and CS_DPL = HZ_DPL of last horizon with HZ_MST of O

If rule is not followed, flag E0 where problem occurs

If HZ_MST = B and HZ_SFX = T then:

CS_DPU = HZ_DPU of 1st Bt horizon and CS_DPL = CS_DPU + 50 if, when the 50 is added it is still in a Bt horizon; if not then CS_DPL = HZ_DPL of last Bt horizon
If rule is not followed, flag E0 where problem occurs

If HZ_MST or HZ_SFX = R then:

1) If HZ_DPL above any horizon where HZ_SFX of "R" occurs is greater than 100, CS_DPU = 025 and CS_DPL = 100; or CS_DPU = 025 and CS_DPL = HZ_DPL of horizon above where HZ_SFX = "R"

2) If HZ_DPL above any horizon where HZ_SFX="R" occurs is greater than 36 and less than 100, CS_DPU = 025 and CS_DPL = HZ_DPL of horizon where HZ_SFX = "R"; or CS_DPU = 025 and CS_DPL = HZ_DPL of horizon above where HZ_SFX = "R

3) If HZ_DPL above any horizon where HZ_SFX of "R" occurs is less than 36, CS_DPU = 000 and CS_DPL = HZ_DPL of horizon where HZ_SFX = "R"; or CS_DPU = 000 and CS_DPL = HZ_DPL of horizon above HZ_SFX of "R"

If rule is not followed, flag E0 where problem occurs

* ER_CLS - leave alone

RNOFC - numeric 1-7
If RNOFC code is missing, flag A0
If RNOFC does not equal a number from 1-7, flag B0
If RNOFC contains alpha characters, flag C0

DIAGNOSTIC FEATURES

If TX_ORD is equal to "E" code, a diagnostic feature is not needed

If TX_ORD is not equal to "E", one set of diagnostic features (DF_DPU1, DF_DPL1, DF_KND1) should be entered, if not flag DF_DPU1, DF_DPL1, DF_KND1 A0

DF_DPU1 (2,3,4,5) - numeric
If DF_DPU1 etc.is not less than DF_DPL1 etc., flag B0

DF_DPL1 (2,3,4,5) - numeric
If DF_DPL1 etc. > DF_DPU2, flag E0

DF_KND1 (2-5) - alpa (see KND codes)
If DF_KND1 etc. does not contain appropriate codes, flag B0
If DF_KND1 etc. contains a numeric character, flag D0

FLOODING

FL_FRQ - alpha
If FL_FRQ is missing, flag A0
If FL_FRQ does not contain codes NO,RA,OC,FR,CO, flag B0
If FL_FRQ contains numeric characters, flag D0

PONDING

PO_FRQ - alpha
IF PO_FRQ is missing, flag A0
IF PO_FRQ does not contain codes NO,RA,OC,FR,CO, flag B0
IF PO_FRQ contains numeric characters, flag D0

VEGETATION

Leave alone - manually checked

DEPTH

HZ_DPU - numeric
If HZ_DPU is missing, flag A0

HZ_DPL - numeric
IF HZ_DPL is missing from any horizon but the last, flag A0
If HZ_MST = "R", HZ_DPL should be blank; if not, flag B0

As you proceed from one horizon to the next, HZ_DPL must be equal to HZ_DPU of the horizon below.

example

horz	depth
01	000 HZ_DPU 005 HZ_DPL
02	005 HZ_DPU 025 HZ_DPL

If this rule is not followed, flag HZ_DPU E0

HORIZON DESIGNATION

* HZ_DSC - numeric
If HZ_DSC is blank, it is assumed to be "1". Numbering starts at "2" with the second layer of contrasting material.

If HZ_DSC equals "1", flag B0
The first non-blank HZ_DSC must be a "2", if not, flag B0
Each proceeding HZ_DSC must be >= the previous HZ_DSC, if not flag the first HZ_DSC where anomoly occurs E0

HZ_MST - alpha
If HZ_MST code is missing, flag A0
If HZ_MST does not contain a letter O,A,E,B C,R, or a combination of these letters, flag B0
If HZ_MST contains numeric values, flag D0

* HZ_SFX - alpha-numeric
If alpha characters not = to A,B,C,E,F,G,I,K,M,N,O,P,R,S,T,V,W,H,X,Y,Z, Flag B0

THICKNESS

HZ_AVG - numeric
If HZ_AVG value is missing, flag A0
IF HZ_AVG is not ≥ HZ_MIN and <= HZ_MAX, flag E0

HZ_MAX - numeric
If HZ_MAX value is missing, flag A0
If HZ_MAX is not ≥ HZ_MIN & HZ_AVG, flag E0

HZ_MIN - numeric
If HZ_MIN value is missing, flag A0
If HZ_MIN not ≤ HZ_MAX & HZ_AVG, flag E0
If HZ_MIN > difference of HZ_DPU and HZ_DPL of same horizon, flag E0

DRY COLOR

If one parameter is filled in, all others on that line of the horizon under this heading, with the possible exception of DC_PCT should be filled in for that horizon; if not flag A0 for that parameter

* DC_LOC1 (2,3) - numeric 0-3
If DC_LOC1 etc. not = to numbers from 0-3, flag B0
If DC_LOC1 etc. contains an alpha character, flag C0

* DC_PCT1 (2,3) - numeric

There are three lines for each horizon. If the same DC_LOC code is used on more than one line for a horizon then a percent must be placed in DC_PCT, if not flag DC_PCT where problem occurs A0

The DC_PCT for a horizon containing the same DC_LOC must add to 90% - 100% if not, flag DC_PCT E0

example

DC_LOC	DC_PCT
1	25
1	75
2	*

* this parameter can be left blank because the DC_LOC value is used only once for this horizon.

* DC_HUE1 (2,3) - alpha-numeric
If numeric part of hue > 10, flag A0
If numeric part not equal to 0, 2.5, 5, 7, 7.5, 10, flag B0

* DC_VAL1 (2,3) - numeric

* DC_CHR1 (2,3) - numeric

MOIST COLOR

If HZ_MST = "O" or "R" or HZ_SFX = "R"; MC_LOC, MC_HUE, MC_VAL, MC_CHR does not need to be filled in. All other horizons must have at least one MC_LOC, MC_HUE, MC_VAL,MC_CHR else flag A0.

* MC_LOC1 (2,3)
* MC_PCT1 (2,3)
* WC_HUE1 (2,3)
* MC_VAL1 (2,3)
* MC_CHR1 (2,3)

There are three lines for each horizon. If the same MC_LOC code is used on more than one line for a horizon then a percent must be placed in MC_PCT, if not flag MC_PCT where problem occurs A0

The MC_PCT for a horizon containing the same MC_LOC must add to 90% - 100% if not, flag MC_PCT E0

TEXTURE

class (TT_CLS1 & TT_CLS2) - alpha (see texture codes)
If HZ_MST does not equal "O" or "R" or HZ_SFX does not equal "R" TT_CLS1 or TT_CLS2 must be filled in; if not, flag A0

If TT_CLS1 or TT_CLS2 does not contain the proper code, flag B0
If TT_CLS1 or TT_CLS2 contains numeric characters, flag D0

If HZ_MST equals "O" or "R" or HZ_SFX equals "R"; TT_CLS1 and TT_CLS2 does not need to be entered.

This next program will have to wait until analytical data is available

There will be a correlation between the texture class codes and the particle size measurements from the analytical laboratories. The following texture classes are defined by this information which should correspond to the analytical particle size information.

Texture Codes

Sands - 85 percent or more sand and a percentage of silt plus 1.5 times the percentage of clay is 15 or less. The following codes are classified under this category:

1) COS   2) S   3) FS   4) VFS

Loamy Sands - At the upper limit 85 to 90 percent sand and the percentage of silt plus twice the percentage of clay exceeds 30; or less than 7 percent clay, less than 50 percent silt, and between 43 and 52 percent sand. The following codes are classified under this category:

1) LCOS   2) LS   3) LFS   4) LVFS

Sandy Loams - 20 percent or less clay and 52 percent or more sand and the percentage of silt plus twice the percentage of clay exceeds 30; or less than 7 percent clay, less than 50 percent silt, and between 43 and 52 percent sand. The following codes are classified under this category:

1) COSL   2) SL   3) FSL   4) VFSL

Loam (L)- 7 to 27 % clay, 28 to 50 % silt, and less than 52 % sand.

Silt Loam (SIL) - 50 % or more silt and 12 to 27 % clay; or 50 to 80 % silt and less than 12 % clay.

Sandy Clay Loam (SCL) - 20 to 35% clay, less than 28% silt, and 45% or more sand.

Silt (SI) - 80 % or more silt and less than 12 % clay.

Clay Loam (CL) - 27 to 40 % clay and 20 to 45 % sand.

Silty Clay Loam (SICL) - 27 to 40 % clay and less than 20 % sand.

Sandy Clay (SC) - 35 % or more clay an 45 % or more sand.

Silty Clay (SIC) - 40 % or more clay and 40 % or more silt.

Clay (C) - 40 % or more clay, less than 45 % sand, and less than 40 % silt.

* MOD (TT_MOD1 & TT_MOD2) - alpha (see modifier codes)
If TT_MOD1 or TT_MOD2 does not contain a correct code, flag B0
If TT_MOD1 or TT_MOD2 contain numeric characters, flag D0

The modifiers are based on % and size of rock fragments (page 4)

RF_PCT (%) 15-35		RF_PCT (%) 36-60		RF_PCT (%) >60	
modifier	size	modifier	size	modifier	size
BY	4	BYV	4	BYX	4
ST	3	STV	3	STX	3
CB	2	CBV	2	CBX	2
CN	5	CNV	5	CNX	5
CR	1-3	CRV	1-3	CRX	1-3
FL	2-3	FLV	2-3	FLX	2-3
GR	1	GRV	1	GRX	1
SH	1-3	SHV	1-3	SHX	1-3
SY	1-3	SYV	1-3	SYX	1-3
GY	1	GYV	1	GYX	1
CBA	2				
CRC	1-3				
GRF	1				
GRC	1				

misc.
SR CY
AY MK
RB PT

For example, if a texture modifier of "BYV" is used in the third horizon, there must be rock fragments of size class three and a percentage (RF_PCT) between 35-60 in the same horizon; if not, flag TT_MOD1 or TT_MOD2 with E0.

STRUCTURE

SR_GRD1 (2,3), SR_SHP1 (2,3), SR_SIZ1 (2,3) - only one matrix needs to be entered; the others may be left blank.

SR_GRD1 (2,3), SR_SHP1 (2,3), SR_SIZ1 (2,3) CS_DRY, CS_MST, CS_OTH, CS_STK, CS_PLC - IF the horizon sequence number equals "1" and the HZ_MST equals "O" or HZ_MST equals "R", none of the parameters indicated need values entered in any of these fields.

SR_GRD1 (2,3) - numeric
If SR_GRD1 etc. code is missing, flag A0
If SR_GRD1 etc. not equal to numbers from 0-6, flag B0
If SR_GRD1 etc. contains alpha characters, flag C0

* SR_SIZ1 (2,3) - alpha
If SR_GRD1 etc. equals "0", SR_SIZ must be blank; if not, flag B0
If SR_GRD1 etc. does not equal "0", SR_SIZ must not be blank; else flag A0
If SR_SIZ1 etc. not equal to EF,VF,FF,F,FM,M,MC,CO,VC,CV,TK,TN, VK,VN, flag B0
If SR_SIZ1 etc. contains numeric characters, flag D0

SR_SHP1 (2,3) - alpha
If SR_SHP1 etc. is code missing, flag A0
If SR_GRD1 etc. equals "0", then SR_SHP must equal "MA" or "SGR"; if not, flag B0
If SR_SHP1 etc. does not equal PL,COL,SBK,CR,WEG,LP,BK, GR,MA,PR,ABK,CDY,SGR, flag B0
If SR_SHP1 etc. contains numeric characters, flag D0

CONSISTENCE

One of these parameters must be filled in for each horizon. The others may be blank; if not, flag all parameters with A0

* CS_DRY - alpha
If CS_DRY does not equal L,S,SH,H,VH,EH, flag B0
If CS_DRY contains numeric character, flag D0

* CS_MST - alpha
If CS_MST does not equal L,VFR,FR,FI,VFI,EFI, flag B0
If CS_MST contains numeric characters, flag D0

* CS_OTH - alpha
If CS_OTH does not equal WSM,SM,MS,B,R,VR,CO,VWC,WC,SC,I,SF,VF,SD flag B0
If CS_OTH contains numeric characters, flag D0

* CS_STK - alpha
If CS_STK does not equal SO,SS,S,VS, flag B0
If CS_STK contains numeric characters flag D0

* CS_PLC - alpha
If CS_PLC does not equal PO,SP,P,VP, flag B0
If CS_PLC contains numeric characters, flag D0

MOTTLES

If one parameter is filled in, all others in that line of the horizon under this heading should be filled in; if not, flag A0 for the missing parameter

* MO_AMT1 (2,3) - alpha
If MO_AMT1 etc. does not equal F,C,M, flag B0
If MO_AMT1 etc. contains numeric characters flag D0

* MO_SIZ1 (2,3) - numeric
If MO_SIZ1 etc. does not equal 1,2,3,12,13, flag B0
If MO_SIZ1 etc. contains alpha characters, flag C0

* MO_CON1 (2,3) - alpha
If MO_CON1 etc. does not equal F,D,P, flag B0
If MO_CON1 etc. contains a numeric character, flag D0

* MO_HUE1 (2,3) - alpha-numeric
If numeric portion of MO_HUE > 10, flag B0

* MO_VAL1 (2,3) - numeric
If MO_VAL1 contains alpha characters, flag C0

* MO_CHR1 (2,3) - numeric
If MO_CHR1 contains alpha characters, flag C0

SURFACE FEATURES

If one parameter is filled in, all others on that line of the horizon, with the exception of SF_HUE, SF_VAL and SF_CHR, should be filled in; if not, flag A0 for the missing parameter.

* SF_KND1 (2,3) - alpha
If SF_KND1 etc. does not = U,B,D,I,Q,L,M,S,X,A,C,G,K,P,O,T, flag B0
If SF_KND1 etc. contains a numeric character, flag D0

* SF_AMT1 (2,3) - alpha
If SF_AMT1 etc. does not equal V,F,C,M, flag B0
If SF_AMT1 etc. contains a numeric character, flag D0

* SF_DCN1 (2,3) - alpha
If SF_DCN1 etc. does not equal P,D,C, flag B0
If SF_DCN1 etc. contains a numeric character flag D0

* SF_DST1 (2,3) - alpha
If SF_DST1 etc. does not equal F,D,P, flag B0
If SF_DST1 etc. contains a numeric character, flag D0

* SF_LOC1 (2,3) - alpha
If SF_LOC1 etc. does not equal P,H,V,Z,U,L,C,M,S,B,R,I,F,T,N, flag B0
If SF_LOC1 etc. contains a numeric character, flag D0

* SF_HUE1 (2,3) - alpha-numeric
If numeric portion of SF_HUE >10, flag B0

* SF_VAL1 (2,3) - numeric
If SF_VAL1 contains alpha characters, flag C0

* SF_CHR1 (2,3) - numeric
If SF_CHR1 contains alpha characters, flag C0

BOUNDARY

If BD_DST and BD_TPG filled in for last horizon, flag F0

BD_DST - alpha
If BD_DST not filled; except for last horizon, flag A0
If BD_DST does not contain A,C,G,D, flag B0
If BD_DST contains a numeric character, flag D0

BD_TPG - alpha
If BD_TPG not filled; except for last horizon, flag A0
If BD_TPG does not equal S,W,I,B, flag B0
If BD_TPG contains a numeric character, flag D0

EFFERVESCENCE

Leave alone

FIELD MEASURED PROPERTIES

FP_KND1 (2-6) - alpha-numeric
If HZ_MST not equal to "O" or "R" or HZ_SFX not equal to "R" and FP_KND1 (2-3) code missing, flag A0
If FP_KND1 does not equal CL,PB,PC,PG,PH,PL,PP,PR,PS,PT,PY,SA,SC, SF,SI,SM,SV,OB,OR, flag B0
If FP_KND1 etc. contains numeric characters flag D0

FP_AMT1 (2-6) - numeric -(no decimals).
If HZ_MST not equal to "O" or "R" or HZ_SFX not equal to "R" and FP_AMT1 (2,3) code missing, flag A0
If FP_AMT contains decimals, flag B0
If FP_AMT contains alpha characters, flag C0

A correlation can be run between field pH for a horizon and the corresponding analytical laboratory pH.

WETNESS

SM_AMT1 - alpha
If HZ_MST not equal to "O" or "R"and SM_AMT1 missing, flag A0
If SM_AMT1 etc. does not equal D,M,W, flag B0
If SM_AMT1 etc. contains numeric values, flag D0

HYDRAULIC CONDUCTIVITY

SM_AMT2 - numeric
If SM_AMT2 code is missing, flag A0
If SM_AMT2 does not equal 1-7, flag B0
If SM_AMT2 contians alpha values, flag

ROOTS

If one parameter is filled in, all others on that line should also be filled in; if not, flag the unfilled areas A0

* RO_AMT1 (2,3) - alpha
If RO_AMT1 (2,3) does not equal VF,FF,F,FC,CM,C,M, flag B0
If RO_AMT1 (2,3) contains numeric values, flag D0

* RO_SIZ1 (2,3) - alpha-numeric
If RO_SIZ1 (2,3) does not = V1,11,1,12,2,23,3,13, flag B0

* RO_LOC1 (2,3) - alpha
If RO_LOC1 (2,3) does not equal C,P,T,M,S, flag B0
If RO_LOC1 (2,3) contains a numeric character, flag D0

Roots should not skip horizons i.e. if there are roots in horizon 2 and 4, there must be roots in horizon 3; if not, flag the three root categories of the suspect horizon E0.

PORES

If one parameter is filled in, all others on that line should also be filled in; if not, flag the unfilled areas A0

* PO_SHP1 (2,3) - alpha
If PO_SHP1 (2,3) does not = IR,IT,TU,TD,TS,VT,IE,IF,TC,TE,
VS,TP, flag B0
If PO_SHP1 (2,3) contains numeric characters, flag D0

* PO_AMT1 (2,3) - alpha
If PO_AMT1 (2,3) does not equal VF,FF,F,FC,CM,C,M, flag B0
If PO_AMT1 (2,3) contains numeric characters, flag D0

* PO_SIZ1 (2,3) - alpha-numeric
If PO_SIZ1 (2,3) does not equal V1,11,1,12,2,23,3,13, flag B0

* PO_CN1 (2,3) - alpha
If PO_CN does not equal L,M,H, flag B0
If PO_CN contains numeric characters, flag D0

CONCENTRATIONS

If one parameter is filled in, all others on that line should also be filled in; if not, flag the unfilled areas A0

* CC_KND1 (2,3) - alpha-numeric (see table kinds of concentrations for values)
If 1st column is not alpha, flag D0
If 2nd column is not numeric, flag C0
If CC_KND1 (2,3) is not a correct value, flag B0

* CC_AMT1 (2,3) - alpha
If CC_AMT1 (2,3) does not equal VF,FF,F,FC,CM,C,M, flag B0
If CC_AMT1 (2,3) contains numeric values, flag D0

* CC_SHP1 (2,3) - alpha
If CC_SHP1 (2,3) does not equal C,D,O,P,T,Z, flag B0
If CC_SHP1 (2,3) contains a numeric character, flag D0

* CC_SIZ1 (2,3) - numeric
If CC_SIZ1 (2,3) does not equal 1,12,2,23,3,4,5,34,45, flag B0
If CC_SIZ1 (2,3) contains alpha characters, flag C0

ROCK FRAGMENTS

If one parameter is filled in, all others on that line of the horizon should be filled in, if not, flag the missing parameters A0.

* RF_KND1 (2-6) - alpha
If RF_KND does not equal Y,S,A,H,K,O,I,B,T,P,F,M,L,E,R, flag B0
If RF_KND contains numeric characters, flag D0

* RF_PCT1 (2-6) - numeric

* RF_SIZ1 (2-6) - numeric
If RF_SIZ1 does not equal a number from 1-6, flag B0
If RF_SIZ1 contains alpha characters, flag C0

Appendix H

Preparation Laboratory Verification Procedures

The following verification procedures are applied to the soil samples received, processed, and analyzed at the preparation laboratory. The computer program is used to track the progress of sample preparation, calculate final values from the raw data, and identify erroneous data. The flags are applied only to the preparation laboratory data and are unrelated to similarly-defined flags in the analytical laboratory data.

PREPARATION LABORATORY COMPUTER ENTRY/TRACKING/VERIFICATION PROCEDURES

The following text provides an overview of the computer tracking and verification program designed for use at the preparation laboratory during the DDRP Mid-Appalachian Soil Survey. The system is designed to track the progress of samples, calculate final data values, perform verification checks, and assign flags to any detected aberrant values.

The program creates the Form 101 that summarizes final data reported by the preparation laboratory. Hard copies of this form are sent to all DDRP cooperating agencies and groups. In addition, the Form 101 is available on floppy disk.

SAMPLE TRACKING

The preparation laboratory manager must track samples as they are received from the sampling crews, during cold storage, through processing and analysis, and during batch formation and shipment to the analytical laboratories. The computer data are used to track the location and progress of each sample while it is physically at the laboratory.

In order to track the sampling activities and shipment/receipt of bulk samples, the following information is to be reported to the QA manager weekly:

- number of samples received
- number of pedons sampled and percentage of total expected
- number of sets received

In order to track the progress of the preparation activities, the following information is to be reported to the QA manager weekly:

- number and percent of samples that have completed specific analyses
- number of bulk samples which are completely processed (excluding bulk density) and are ready to be batched
- number of sets that have been completed
- number of batches sent to analytical laboratories

DATA VERIFICATION

The system allows the entry and editing of data by preparation laboratory personnel and the review of progress and data analysis by the QA staff. After a run of data is entered into a "temporary" data file, the final values are calculated and verified. A printout of this information is checked by the preparation laboratory manager and by a representative from the QA staff. The data that have satisfied the verification criteria are then moved into a "master" data file which is used to track progress and percentages of the analyses that have been completed. The master file cannot be edited by preparation laboratory personnel.

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The five raw data forms that are entered into the computer are: (1) sample receipt raw data form, (2) clod bulk density raw data form, (3) known volume bulk density raw data form, (4) loss on ignition raw data form, and (5) bulk sample processing raw data form. In the descriptions of the forms below, a list of the data calculations, verification checks, and pertinent verification flags are included. At the beginning of each description is a list of the data from each particular form which must be transferred to the Form 101. The flags consist of two characters, an alpha character and a numeric character. The numeric character designates which data form the flag pertains to, e.g., a flag with the numeric character "3" pertains to the known volume raw data form.

SUMMARY OF VERIFICATION FLAGS

Sample Receipt Raw Data Form

A1	Missing data on form
B1	Sample code mislabeled
C1	Site ID mislabeled
D1	More than 2 known volume samples
E1	More than 3 clods

Clod Bulk Density Raw Data Form

A2	Missing data on form
B2	Submerged clod weight ≥ Lab clod weight, and clod did not float
C2	Clod floated
D2	Problem clod (deletes value from average)
E2	Oven-dry clod weight > Lab clod weight
F2	Oven-dry clod weight > Field-moist clod weight
G2	Coefficient of variation > 20 among replicates
H2	Bulk density > 2.0
I2	Bulk density < 1.0
J2	Sample code not recorded same as on sample receipt form
K2	Number of replicates not recorded same as on sample receipt form
L2	Replicates > 3

Known Volume Bulk Density Raw Data Form

A3	Missing data on form
B3	Oven-dry weight ≥ Air-dry weight
C3	Weight of fines + Rock fragments > Air-dry weight
D3	Sample code not recorded same as on sample receipt form
E3	Number of replicates not recorded same as on sample receipt form
F3	Bulk density > 2.0
G3	Bulk density < 1.0
H3	Coefficient of variation > 20 among replicates
I3	Impossible value because of error in raw data

Loss on Ignition Raw Data Form

A4	Missing data on form
B4	Organic matter > 100%
C4	Oven-dry weight > Air-dry weight
D4	Ashed weight > Oven-dry weight
E4	Sample code not recorded same as on sample receipt form
F4	Sample analysis duplicated
G4	Organic soil type not correlating
H4	Mineral soil type not correlating
I4	Internal duplicate/routine pair > 15% RSD
J4	FAP samples > 15% RSD
K4	Field duplicate/routine sample > 20% RSD
L4	FAL sample outside accuracy window
M4	FAP sample outside accuracy window
N4	Manager's sample outside accuracy window

Bulk Sample Processing Raw Data Form

A5	Missing data on form
B5	Mineral soil air-dry moisture > 2.5%
C5	Organic soil air-dry moisture > 6.0%
D5	Field-moist pH > 6.0
E5	Sample code not recorded same as on sample receipt form
F5	Internal duplicate/routine sample > 15% RSD
G5	Field duplicate/routine sample > 20% RSD
H5	FAP samples > 15% RSD
I5	pH QCCS buffer < 3.95 or > 4.05
J5	Manager's sample outside accuracy window
K5	FAP sample outside accuracy window

SAMPLE RECEIPT RAW DATA FORM

Form 101 Information:

SAM_CODE
SITE_ID
SET_ID

General:

ERL-C provides EMSL-LV with the pedon number (state, county, unit) and site ID for each pedon to be sampled. This information is placed in the data base before preparation activities begin.

All samples received from the field and their condition are recorded on the sample receipt raw data form and immediately entered into the data base. A file comparison procedure is initiated, comparing the pedon number and site ID with the raw data from the sample receipt form. If any discrepancies are found, processing of the affected samples ceases until the discrepancies are rectified.

All flags for the receipt data are unique and identified by the numeric character "1".

After all verification checks for the sample receipt data have been satisfied, the data are sorted by set ID. All samples with the same set ID will undergo processing simultaneously.

Calculations:

No calculations are to be performed on the sample receipt form.

Verification Flags

If any data are missing on the form; then flag A1
If sample code is mislabeled; then flag B1
If site ID is mislabeled; then flag C1
If more than 2 known volume samples are recorded; then flag D1
If more than 3 clods are recorded; then flag E1

When flags other than D1 and E1 are generated, processing of the affected samples must cease until the problem is rectified.

Reporting:

The computer produces a printout, sorted by SET_ID and SAM_CODE, that lists all flags assigned.

CLOD BULK DENSITY RAW DATA FORM

Form 101 Information:

BD_CLD

General:

The clod data are entered into a temporary working file. The verification program should be run on a regular basis and the discrepancy printout generated. All flags for the clod data are unique and identified by the numeric character "2".

After all verification checks for the clod data have been satisfied, the data are sorted by set ID and sample code. All samples with the same set ID will undergo processing simultaneously.

Calculations:

SARAN_WT (g) = (FIELD_DP + LAB_DP) * (LAB_WT - FLD_WT) / LAB_DP

OD_SAR (g) = SARAN_WT * 0.85

SARAN VOL (cm^3) = SARAN_WT / 1.30

R_FRAG VOL (cm^3) = R_FRAG / 2.47

WATER VOL (cm^3) = CLOD_H2O / WT_DEN

SOIL/PORES VOL (cm^3) = WATER VOL - (R_FRAG VOL + SARAN VOL)

BD_CLD (g/cm^3) = [LAB_WT - (R_FRAG + OD SARAN_WT + 1.88)] / SOIL/PORES VOL - 0.20

Verification Flags:

If any parameter field is blank, except for 'COMMENTS'; then flag A2
If CLOD_H2O > LAB_WT and FLOAT not marked 'Y'; then flag B2
If FLOAT is marked "Y"; then flag C2
If PROB is marked "Y"; then flag D2 (deletes value from average)
If FIELD_WT > LAB_WT; then flag E2
If CLOD_OD > FIELD_WT; then flag F2
If CV > 20; then flag G2
If BD_CLD > 2.0; then flag H2
If BD_CLD < 1.0; then flag I2
If a SAM_CODE does not match the receipt file; then flag J2
If REP does not match the receipt file; then flag K2
If REP > 3; then flag L2

Reporting:

For each SAM_CODE there are usually 3 replicates, although this number varies. Therefore, a check for replicate consistency is necessary. If the PROB column is marked "Y" for any replicate in a SAM_CODE, this replicate should not be included in the following calculation.

The computer produces a printout, sorted by SET_ID, SAM_CODE, and REP, that lists all flags assigned. For each SAM_CODE, the mean, standard deviation, and coefficient of variation of all replicates are listed.

The number of horizons and the percentage of the total number of samples having clods are reported.

KNOWN VOLUME BULK DENSITY RAW DATA FORM

Form 101 Information:

BD_KV

General:

Known volume samples are taken from those horizons where clods cannot be extracted.

Calculations:

FINES_WT (g) = (OD_WT - R_FRAG - BAG_WT)

BD_KV (g/cm^3) = FINES_WT / (VOL - (R_FRAG / particle density)

Verification Flags:

If any parameter field is blank, with the exception of 'COMMENTS'; then flag A3
If OD_WT ≥ AIR_WT; then flag B3
If FINES_WT + R_FRAG > AIR_WT; then flag C3
If a SAM_CODE does not match the receipt form; then flag D3
If REP does not match the receipt form; then flag E3
If BD_KV > 2.0; then flag F3
If BD_KV < 1.0; then flag G3
If CV > 20; then flag H3

Reporting:

The computer produces a printout, sorted by SET_ID, SAM_CODE, and REP, that lists all flags assigned. For each SAM_CODE, the mean, standard deviation, and coefficient of variation of all replicates are listed.

The number of horizons and the percentage of the total number of samples having known volume samples are reported.

LOSS ON IGNITION RAW DATA FORM

Form 101 Information:

OM_LOI

Calculations:

Each CRUC_NO will be associated with a pre-determined CRUC_WT.

OM_LOI = [(OD_WT - ASHED_WT) / (OD_WT - CRUC_WT)] * 100

Verification Flags:

If any parameter field is blank, with the exception of 'COMMENTS'; then flag A4
If OM_LOI ≥ 100; then flag B4
If OD_WT > AIR_WT; then flag C4
If ASHED_WT > OD_WT; then flag D4
If a SAM_CODE does not match the receipt file; then flag E4
If the SAM_CODE is duplicated on the LOI form; then flag F4
If OM_LOI ≥ 20 and SOILTYP on the bulk sample form is not "O"; then flag G4
If OM_LOI < 20 and SOILTYP on the bulk sample form is not "M"; then flag H4
If the internal duplicate/routine pair is > 15% RSD; then flag I4

If the FAP samples > 15% RSD; then flag J4
If the field duplicate/routine pair > 20% RSD; then flag K4
If a FAL sample is outside accuracy window; then flag L4
If a FAP sample is outside accuracy window; then flag M4
If a MS is outside accuracy window; then flag N4

Reporting:

The computer produces a printout, sorted by SET_ID and SAM_CODE, that lists all flags assigned.

The number of horizons and the percentage of the total number of samples that have been analyzed are reported.

BULK SAMPLE PROCESSING RAW DATA FORM

Form 101 Information:

PH_MP
MOIST_P (1,2,3)
RF_FG
RF_MG

General:

General information concerning the bulk sample is recorded on this form. When the form is complete, the sample is considered ready to be batched and shipped to an analytical laboratory.

Calculations:

PH_MP (no calculation required)

MOIST_P (1, 2, 3) = [(INIT_WT1 - OD_WT / (OD_WT - TIN_WT)] * 100

Each MOIST_P calculation will be conducted only if the previous MOIST_P is > 2.5 percent for mineral samples or > 6.0 percent for organic samples.

RF_FG = (RF_FGRAW / A_BULK) * 100

RF_MG = (RF_MGRAW / A_BULK) * 100

Verification Flags:

If any parameter field is blank, with the exception of 'COMMENTS'; then flag A5
If SOILTYP = 'M' and MOIST_P (1,2,3) > 2.5; then flag B5
If SOILTYP = 'O' and MOIST_P (1,2,3) > 6.0; then flag C5
If PH_MP > 6.0; then flag D5
If a SAM_CODE does not match the receipt file; then flag E5
If the internal duplicate/routine pair > 15% RSD; then flag F5

If the field duplicate/routine pair for MOIST_P, RF_FG, or RF_MG > 20% RSD; then flag G5 (or >0.20 SD for PH_MP)
If the FAP samples for MOIST_P, RF_FG, or RF_MG > 15% RSD; then flag H5 (or 0.15 SD for PH_MP)
If pH QCCS out of window; then flag I5
If MOIST_P is outside accuracy window; then flag J5
If PH_MP is outside accuracy window; then flag K5

Reporting:

The computer produces a printout, sorted by SET_ID and SAM_CODE, that lists all flags assigned.

The number of horizons and the percentage of the total number of samples that have been analyzed are reported.

pH

MASS PREP LAB DATA REVIEW

Sample Date	FAP acc/prec	FAL acc	Buffer	Int Dup (0.15 SD)	Field Dup (0.20 SD)	Manager sample acc.	PASS

AIR DRY MOISTURE

MASS PREP LAB DATA REVIEW

Sample Date	FAP acc/prec (15%RSD)	FAL acc	Int Dup (15% RSD)	Field Dup (20% RSD)	Manager sample (control)	PASS

LOSS ON IGNITION

MASS PREP LAB DATA REVIEW

Sample Date	FAP acc/prec (15%RSD)	FAL acc	Int Dup (15% RSD)	Field Dup (20% RSD)	Manager sample (control)	PASS

Appendix I

Preparation Laboratory On-Site Evaluation Questionnaire

The following questionnaire is used to provide documentation of on-site audits of the preparation laboratory by QA staff. Generally, the preparation laboratory is evaluated at least twice. The first audit is conducted before samples are received in order to assess the ability of the laboratory, in terms of personnel, facilities, and equipment, to process soil samples successfully. At the time of the second evaluation, adherence to the Preparation Laboratory Standard Operating Procedures is evaluated and specific discrepancies are addressed.

Lockheed-ESC PREPARATION LABORATORY ON-SITE BIWEEKLY EVALUATION QUESTIONNAIRE

Date: ____________________

Laboratory Telephone Number: ____________________

Laboratory Manager: ____________________

Laboratory Quality Assurance Officer: ____________________

Technicians Present During Evaluation: ____________________
____
____
____

General

Questions	Yes	No	Comments
Is the overall appearance of the laboratory clean?			
Is there proper storage/ disposal of chemicals and hazardous materials?			
Are safety stickers properly displayed?			
Are the fire extinguishers in place?			
Date of last service call for fire extinguishers?			
Is there a disposal system for paper, etc.?			
Is the air compressor accessible to all areas of the laboratory?			
Is there an adequate supply of gloves, goggles, DDI H20, paper towels, etc.?			
Is there a copy of the SOP available to technicians?			
Is there an updated record of instrument calibrations?			
Are the computer records kept up-to-date?			
Is the eye wash station easily accessible in case of emergency?			
Is the power box easily accessible in case of emergency shutoff?			

Comments:

Cold Storage Room

Questions	Yes	No	Comments
Is there adequate space for sample storage?			
Is there easy access to samples?			
Is the temperature of the cold storage kept at $4^{\circ}C$ +/- $2^{\circ}C$?			
Is a systematic way of shelving and locating samples being maintained?			
Is there clear and precise labeling of samples?			
Are samples being kept in an area free from moisture and contamination?			
Are samples tightly sealed?			
Is there clear separation of organic and mineral samples?			
Is the cold storage room clean?			
Is the floor area clean of samples?			

Comments:

Sample Drying

Questions	Yes	No	Comments
Are all samples covered and free from contamination while drying?			
Are samples that are spread to dry properly labeled?			
Are gloves being used to mix the samples?			
Is the bulk sample form filled out for each sample drying?			
Is the paper being changed as needed during drying?			
Is the air flow being maintained?			
Are the doors closed?			
Is the drying area clean?			
Are cleaning protocols being followed?			

Comments:

Sample Preparation

Questions	Yes	No	Comments
Are proper sample grinding procedures being followed?			
Are proper cleaning procedures between samples being followed?			
Is the preparation room clean?			
Are the fans being used during sample preparation?			

Comments:

pH

Questions	Yes	No	Comments
Is there an up-to-date calibration curve for pH determinations?			
Is there an up-to-date QCCS log for pH determinations?			
Are pH electrodes stored properly?			
Is there enough filling solution in the electrode?			
Is the procedure for pH determination being followed according to the SOP?			

Comments:

Moisture and Loss On Ignition

Questions	Yes	No	Comments
Is the sample used to determine field moisture properly secured from contamination prior to the loss on ignition determination?			
Are the oven and crucibles cleaned between each set of samples?			
Are crucibles clearly numbered?			
Are the muffle furnace and desiccators clean?			
Are oven and furnace hazards clearly posted?			
Are oven gloves in good condition?			
Are the platinum-tipped tongs being used consistently when moving the crucibles?			

Comments:

Procedures During Sample Riffle Splitting

Questions	Yes	No	Comments
Is there proper cleaning of riffle-splitter and sieves?			
Is the door closed?			
Is the fan operating?			
Is the trailer used only by personnel performing the riffle-splitting?			

General

Questions	Yes	No	Comments
Is the trailer clean?			
Is the balance clean?			
Are record books updated?			
Are rock fragments labeled and stored properly?			
Are the three riffle-split subsamples clearly labeled?			
Do the technicians understand and practice the procedures properly?			

Comments:

Bulk Density

Questions	Yes	No	Comments
Is there proper mixing of the saran and acetone?			
Is there proper sealing of the saran/acetone to prevent evaporation?			
Are the clods labeled properly?			
Are the procedures for both bulk densities being followed?			
Are all weights recorded to the nearest .01g?			
Do technicians know the proper procedure for a clod that floats?			
Are evaporating dishes clearly labeled?			

Comments:

Appendix J

Quality Assurance Reanalysis Templates

The following QARTs are used in the evaluation of QE/QC and routine sample data. As a batch of soils data is received, it is reviewed according to the criteria set forth in the template. If major uncertainty or a large occurrence of minor uncertainty is identified, confirmation or reanalysis is requested for the affected parameter and batch.

PARAMETER: PH_MP

	MAJOR	MINOR	NON
Field Audit Low & Pair	If any 2 of 3 relationships occur and 2 minor flag occurs: 1) FAL beyond control limits 2) Mean of FAP or FAO beyond control limits 3) FAP or FAO SD > 0.15	If 1 of 3 of the relationships listed in the major column occurs	If 0 of 3 of the relationships listed in the major column occur
QCCS	Out of expected range	none	within expected range
Internal duplicate	none	Routine/duplicate SD > 0.15	Routine/duplicate SD < 0.15
Field duplicate	none	Routine/duplicate SD > 0.20	Routine/duplicate SD < 0.20
Manager sample	none	Sample beyond control limits	Sample within control limits

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Field-Moist pH.

PARAMETER: OM_LOI

	MAJOR	MINOR	NON
Field Audit Low & Pair	If any 2 of 3 relationships occur and 1 minor flag occurs: 1) FAL beyond control limits 2) Mean of FAP or FAO beyond control limits 3) FAP or FAO RSD > 15%	If 1 of 3 of the relationships listed in the major column occurs	If 0 of 3 of the relationships listed in the major column occur
Internal duplicate	none	Routine/duplicate RSD > 15%	Routine/duplicate RSD < 15%
Field duplicate	none	Routine/duplicate RSD > 20%	Routine/duplicate RSD < 20%
Manager sample	none	Sample beyond control limits	Sample within control limits

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Organic Matter by Loss on Ignition.

PARAMETER: MOIST_P

	MAJOR	MINOR	NON
Field Audit Low & Pair	If any 2 of three of relationships occur and one minor flag occurs: 1) FAL beyond control limits 2) Mean of FAP or FAO beyond control limits 3) FAP or FAO RSD > 20%	If 1 of 3 of the relationships occur listed in major column occurs	If 0 of 3 of the relationships listed in the major column occur
Internal duplicate	none	Routine/duplicate RSD > 15%	Routine/duplicate RSD < 15%
Field duplicate	none	Routine/duplicate RSD > 20%	Routine/duplicate RSD < 20%
Manager sample	none	Sample beyond control limits	Sample within control limits

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Air-Dry Moisture.

PARAMETER: SAND, SILT

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > 3.0 if value at lower limit 2) prep dup/field dup pair: SD > 3.0 if value at lower limit 3) mean value lab audits out of accuracy window, or SD > 3.0 if value at lower limit 4) low level lab audit out of accuracy window	If 1 out of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > 6.0 if value at lower limit	Within batch precision: SD < 6.0 if valur at lower limit
Soil Chemistry Relationships	NONE	NONE	NONE
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Sand and Silt.

PARAMETER: CLAY

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of the 4 relationships occur: 1) prep dup/routine pair: SD > 2.0 if value at lower limit 2) prep dup/field dup pair: SD > 2.0 if value at lower limit 3) mean value lab audits out of accuracy window, or SD > 2.0 if value at lower limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > 4.0 if value at lower limit	Within batch precision: SD < 4.0 if value at lower limit
Soil Chemistry Relationships	If any relationship occurs ≥ 6 times: CEC_OAC/CLAY > 50 if clay > 1.0 and CEC_CL > 1 meq/100 g CEC-CL/CLAY > 50 if clay > 1.0 and CEC-CL > 1 meq/100 g	If relationships occur < 6 times	If relationships do not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Clay.

PARAMETER: PH_H20, PH_002M, PH_01M

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > 0.1 if value at lower limit 2) prep dup/field dup pair: SD > 0.1 if value at lower limit 3) mean value lab audits out of accuracy window, or SD > 0.1 if value at lower limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > 0.2 if value at lower limit	Within batch precision: SD < 0.2 if value at lower limit
Soil Chemistry Relationships	If relationship occurs ≥ 6 times PH_H20 < PH_002M < PH_01M if difference > .05	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Soil pH.

PARAMETER: CA, MG, NA, K_CL
CA, MG, NA, K_OAC

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .02 if value at lower limit %RSD > 15% if value at upper limit 2) prep dup/field dup pair: SD > .02 if value at lower limit %RSD > 15% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > .02 if value at lower limit %RSD > 10% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	none	Within batch precision: SD > .04 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD < .04 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	If relationships occur ≥ 6 times: CA_OAC + MG_OAC + NA_OAC + K_OAC > CEC_OAC if CEC_CL > 1 meq/100 g CA_CL + MG_CL + NA_CL + K_CL > CEC_CL if CEC_CL > 1 meq/100 g	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of the Exchangeable Cations In Ammonium Chloride and Ammonium Acetate.

PARAMETER: AL_CL

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .20 if value at lower limit %RSD > 22% if value at upper limit 2) prep dup/field dup pair: SD > .20 if value at lower limit %RSD > 22% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > .20 if value at lower limit %RSD > 15% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > 5.0 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD < 5.0 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	If relationship occurs ≥ 6 times: AL_CL > 0.1 meq/100 g if pH_H2O > 6.0	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Aluminum in Ammonium Chloride.

PARAMETER: CEC_OAC, CEC_CL

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .25 if value at lower limit %RSD > 15% if value at upper limit 2) prep dup/field dup pair: SD > .25 if value at lower limit %RSD > 15% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > .25 if value at lower limit %RSD > 10% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .50 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD < .50 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	If relationship occurs $\geq$ 6 times CEC_OAC < CEC_CL if CEC_CL > 1 meq/100 g and PH_H2O < 7.0	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Cation Exchange Capacity in Ammonium Chloride and Ammonium Acetate.

PARAMETER: AC_BACL

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > 1.0 if value at lower limit %RSD > 22% if value at upper limit 2) prep dup/field dup pair: SD > 1.0 if value at lower limit %RSD > 22% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > 1.0 if value at lower limit %RSD > 15% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > 2.0 if value at lower limit %RSD > 45% when using upper limit	Within batch precision: SD < 2.0 when using lower limit %SDR < 45% when using upper limit
Soil Chemistry Relationships	NONE	NONE	NONE
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Barium Chloride Exchangeable Acidity.

PARAMETER: CA_CL2

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .05 if value at lower limit %RSD > 8% if value at upper limit 2) prep dup/field dup pair: SD > .05 if value at lower limit %RSD > 8% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > .05 if value at lower limit %RSD > 5% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 or the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .10 if value at lower limit %RSD > 15% if value at upper limit	Within batch precision: SD < .10 if value at lower limit %RSD < 15% if value at upper limit
Soil Chemistry Relationships	NONE	NONE	NONE
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanalysis Template for the Determination of Extractable Calcium in Calcium Chloride.

PARAMETER: MG_CL2, NA_CL2, K_CL2

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD >.005 if value at lower limit %RSD > 15% if value at upper limit 2)prep dup/field dup pair: SD >.005 if value at lower limit %RSD > 15% if value at upper limit 3) mean value lab audits out of accuracy window, or SD >.005 if value at lower limit %RSD > 10% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .010 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD < .010 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	If relationship occurs ≥ 6 times MG_CL2 > MG_CL * 1.10 if MG_CL2 > 10 * CRDL NA_CL2 > NA_CL * 1.10 if NA_CL2 > 10 * CRDL K_CL2 > K_CL * 1.10 if K_CL2 > 10 * CRDL	If relationships occur < 6 times	If relationships do not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Extractable Magnesium, Potassium, and Sodium in Calcium Chloride.

PARAMETER: FE_CL2

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .01 if value at lower limit %RSD > 22% if value at upper limit 2) prep dup/field dup pair: SD > .01 if value at lower limit %RSD > 22% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > .01 if value at lower limit %RSD > 15% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .02 if value at lower limit %RSD > 45% if value at upper limit	Within batch precision: SD < .02 if value at lower limit %RSD < 45% if value at upper limit
Soil Chemistry Relationships	NONE	NONE	NONE
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Extractable Iron in Calcium Chloride.

PARAMETER: AL_CL2

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .05 if value at lower limit %RSD > 22% if value at upper limit 2) prep dup/field dup pair: SD > .05 if value at lower limit %RSD > 22% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > .05 if value at lower limit %RSD > 15% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .10 if value at lower limit %RSD > 45% if value at upper limit	Within batch precision: SD < .10 if value at lower limit %RSD < 45% if value at upper limit
Soil Chemistry Relationships	NONE	NONE	NONE
Internal Relationships	> 10 outliers	5 - 10 outliers	> 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Extractable Aluminum in Calcium Chloride.

PARAMETER: FE_PYP, AL_PYP, FE_AO, AL_AO, SI_AO, FE_CD, AL_CD

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .03 if value at lower limit %RSD > 15% if value at upper limit 2) prep dup/field dup pair: SD > .03 if value at lower limit %RSD > 15% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > .03 if value at lower limit %RSD > 10% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .06 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD < .06 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	NONE	NONE	NONE
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Extractable Iron, Aluminum, and Silicon in Pyrophosphate, Acid Oxalate, and Citrate Dithionite.

PARAMETER: SO4_PO4, SO4_H2O

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > 1.5 if value at lower limit %RSD > 15% if value at upper limit 2) prep dup/field dup pair: SD > 1.5 if value at lower limit %RSD > 15% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > 1.5 if value at lower limit %RSD > 5% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > 3.0 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD < 3.0 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	If relationship occurs ≥ 6 times SO4_PO4 < SO4_H2O if SO4_H2O > 1 mg S/kg soil SO4_H2O/SO4_0 > 4 or SO4_H2O/SO4_0 > 20 if SO4_H2O ≥ 2 mg S/kg and SO4_0 ≥ .1 mg S/kg	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Extractable Sulfate In Water and Phosphate.

PARAMETER: SO4_0-32

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .10 if value at lower limit %RSD > 8% if value at upper limit 2) prep dup/field dup pair: SD > .10 if value at lower limit %RSD > 8% if value at lower limit 3) mean value lab audits out of accuracy window, or SD > .10 if value at lower limit %RSD > 5% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occur	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .20 if value at lower limit %RSD > 15% if value at upper limit	Within batch precision: SD < .20 if value at lower limit %RSD < 15% if value at upper limit
Soil Chemistry Relationships	If relationship occurs ≥ 6 times SO4_32 < SO4_16 < SO4_8 < SO4_4 < SO4_2 < SO4_0 If SO4_32N >= 7.5 mg S/Kg soil	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Sulfate Adsorption Isotherms.

PARAMETER: C_TOT

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD > .05 if value at lower limit %RSD > 15% if value at upper limit 2) prep dup/field dup pair: SD > .05 if value at lower limit %RSD > 15% if value at upper limit 3) mean value lab audits out of accuracy window, or SD > .05 if value at lower limit %RSD > 10% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .10 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD < .10 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	If any relationship occurs ≥ 6 times C_TOT/N_TOT < 7 or C_TOT/N_TOT > 50 if N_TOT ≥ .03 wt% and C_TOT ≥ .1 wt% C_TOT/S_TOT < 40 or C_TOT/S_TOT > 400 if S_TOT ≥ .005 wt% and C_TOT ≥ .1 wt%	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Total Carbon.

PARAMETER: N_TOT

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD >.015 if value at lower limit %RSD > 15% if value at upper limit 2) prep dup/field dup pair: SD >.015 if value at lower limit %RSD > 15% if value at upper limit 3) mean value lab audits out of accuracy window, or SD >.015 if value at lower limit %RSD > 10% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .03 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD < .03 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	If relationship occurs ≥ 6 times C_TOT/N_TOT < 7 or C_TOT/N_TOT > 50 if N_TOT ≥ .03 wt% and C_TOT ≥ .1 wt%	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Total Nitrogen.

PARAMETER: S_TOT

	MAJOR	MINOR	NON
Lab Audits & Prep Dups	If any 2 of 4 relationships occur: 1) prep dup/routine pair: SD >.002 if value at lower limit %RSD > 15% if value at upper limit 2) prep dup/field dup pair: SD >.002 if value at lower limit %RSD > 15% if value at upper limit 3) mean value lab audits out of accuracy window, or SD >.002 if value at lower limit %RSD > 10% if value at upper limit 4) low level lab audit out of accuracy window	If 1 of 4 of the relationships listed in the major column occurs	If 0 of 4 of the relationships listed in the major column occur
Field Dups & Field Audits	NONE	Within batch precision: SD > .004 if value at lower limit %RSD > 30% if value at upper limit	Within batch precision: SD <.004 if value at lower limit %RSD < 30% if value at upper limit
Soil Chemistry Relationships	If relationship occur $\geq$ 6 times C_TOT/S_TOT < 40 or C_TOT/S_TOT > 400 if S_TOT $\geq$ .005 wt% and C_TOT $\geq$ .1 wt%	If relationship occurs < 6 times	If relationship does not occur
Internal Relationships	> 10 outliers	5 - 10 outliers	< 5 outliers

Reanalysis is requested with occurrence of 1 major or 3 minor & uncertainty

Quality Assurance Reanlysis Template for the Determination of Total Sulfur.

Appendix K

Analytical Data Verification and Validation Flags

This appendix lists the data qualifiers, or flags, that are assigned to the verified and validated data bases. The verification flags specify the nature of discrepancies on a batch and sample basis, while the validation flags are used to characterize more general types of discrepancies that may affect the level of confidence applied to each datum in the validated data base. The verification flags are applied only to the analytical laboratory data and are unrelated to similarly-defined flags in the preparation laboratory data.

ANALYTICAL DATA VERIFICATION FLAGS

Blank Exception Program

B4**	Potential negative sample bias based on laboratory blank data.
B5**	Reagent blank mean is > CRDL.
B6*	Laboratory calibration blanks or reagent blanks are > CRDL.
B9**	Insufficient number of calibration blanks were run.

Duplicate Precision Exception Program

D1**	Analytical duplicate (AD/routine) precision exceeds the maximum expected SD or %RSD.
D5**	Preparation duplicate (PDF/routine) precision exceeds the maximum expected SD or %RSD.
D6**	Preparation duplicate (PDR/routine) precision exceeds the maximum expected SD or %RSD.
D7**	Field audit pair/triplicate (FAP/FAO) precision exceeds the maximum expected SD or %RSD.
D8**	Laboratory audit pair/triplicate (LAP/LAO) precision exceeds the maximum expected SD or %RSD.
D9**	Field duplicate (FD/routine) precision exceeds the maximum expected SD or %RSD.

Detection Limit Exception Program

L1**	Instrument detection limit (IDL) exceeds contract-required detection limit (CRDL).

Audit Accuracy Program

N0**	Low-range laboratory audit (LAL) sample value exceeds upper accuracy limit.
N1**	LAL sample is below lower accuracy limit.
N2**	Mean of LAP or LAO exceeds upper accuracy limit.
N3**	Mean of LAP or LAO is below lower accuracy limit.
N4**	Quality control audit sample (QCAS) exceeds upper accuracy limit.
N5**	QCAS is below lower accuracy limit.

(Continued)

QCCS Exception Program

Q1**	Quality control check sample (QCCS) exceeds upper control limit.
Q2**	QCCS is below lower control limit.
Q3**	Insufficient quantity of QCCS were measured.
Q4**	Detection limit QCCS is not within 20% of the theoretical concentration.

Matrix Spike Program

S1**	Percent recovery of matrix spike is above contractual criteria (>105% for sulfur parameters, >110% for all others).
S2**	Percent recovery of matrix spike is below contractual criteria (<95% for sulfur parameters, <90% for all others).
S3**	Spike solution readings are outside of contractual criteria (sulfate isotherm parameters only).

Miscellaneous

A0*	Value missing
M0*	Value was obtained by using a method that is unacceptable according to the contract.
W0*	Air-dry sample weight is not within contractual requirement.
W2*	Sample extract volume is not within contractual requirement.
X0*	Invalid but confirmed data based on review of QE/QC data.
X1*	Invalid but confirmed data - potential gross contamination of sample or parameter.
X2*	Invalid but confirmed data - potential gross contamination of pedon.
X3*	Possible contamination due to either sampling technique, e.g., bucket augering, or soil amendments, e.g. herbicides, liming, manure, etc.
X4*	Outliers from statistical internal consistency check; raw data and reported data checked only for transcription errors.
X5*	Outliers from manual pedon/horizon internal consistency check; raw data and reported data checked only for transcription errors.

(Continued)

Soil Chemistry Relationships

NC* Not checked because basic initial criteria were not met.

C1* PH_H20 < PH_002M if pH differences > 0.05 units.

C2* PH_002M < PH_01M if pH differences > 0.05 units.

C3* PH_H20 < PH_01M if pH differences > 0.05 units.

C4* CEC_OAC < CEC_CL if CEC_CL > 1 meq/100g and PH_H2O < 7.0

C5* CA_OAC + MG_OAC + K_OAC + NA_OAC > CEC_OAC if CEC_CL > 1 meq/100g

C6* CA_CL + MG_CL + K_CL + NA_CL > CEC_CL if CEC_CL > 1 meq/100g

C7* CEC_OAC/CLAY > 50 if CLAY > 1.0% and CEC_CL > 1 meq/100g

C8* CEC_CL/CLAY > 50 if CLAY > 1.0% and CEC_CL > 1 meq/100g

C9* AL_CL > 0.01 meq/100g if PH_H2O > 6.0

T1* C_TOT/S_TOT < 7 or > 50 if C_TOT ≥ 0.1% and N_TOT ≥ 0.03%.

T2* C_TOT/N_TOT < 40 or > 400 if C_TOT ≥ 0.1% and N_TOT ≥ 0.03%.

I1* SO4_32 < SO4_16 if SO4_32N ≤ 7.5 mg S/kg soil.

I2* SO4_16 < SO4_8 if SO4_32N ≤ 7.5 mg S/kg soil.

I3* SO4_8 < SO4_4 if SO4_32N ≤ 7.5 mg S/kg soil.

I4* SO4_4 < SO4_2 if SO4_32N ≤ 7.5 mg S/kg soil.

I5* SO4_2 < SO4_0 if SO4_32N ≤ 7.5 mg S/kg soil.

I6* SO4_32N < SO4_16N if SO4_32N ≥ 7.5 mg S/kg soil.

I7* SO4_16N < SO4_8N if SO4_32N ≥ 7.5 mg S/kg soil.

I8* SO4_8N < SO4_4N if SO4_32N ≥ 7.5 mg S/kg soil.

I9* SO4_4N < SO4_2N if SO4_32N ≥ 7.5 mg S/kg soil.

I0* SO4_2N < SO4_0N if SO4_32N ≥ 7.5 mg S/kg soil.

R1* SO4_H2O > SO4_PO4 if SO4_PO4 > 1 mg S/kg soil (mineral samples); SO4_H2O > SO4_PO4 * 1.10 (organic samples).

(Continued)

R2*	SO4_H2O/SO4_0 < 4 or > 20 if SO4_H2O ≥ 2 mg S/kg and SO4_0 ≥ 0.1 mg S/kg.
H1*	NA_CL2 > NA_CL * 1.10 if NA_CL2 > 0.03 meq/100g.
H2*	K_CL2 > K_CL * 1.10 if K_CL2 > 0.003 meq/100g.
H3*	MG_CL2 > MG_CL * 1.10 if MG_CL2 > 0.008 meq/100g.

* Sample Flag: flags the affected parameter for specified samples only.
** Batch-wide Flag: flags the affected parameter for all samples in the batch (assumes that measurement quality samples are representative for the batch).

ANALYTICAL DATA VALIDATION FLAGS

V1	Datum > ±3x interquartile range limits or > ±1.5x interquartile range limits; has verification flag type K, W, M, or X
V2	QE/QC data outside expected ranges
V3*	Horizon aggregation problem
V4	Misclassification in sampling class
V5*	Field data notes indicate a problem
V6	Sample contaminated but internally consistent pedon chemistry; verification flag for individual outlier
V7**	Double check for use in aggregating
V8**	Internally inconsistent chemistry
V9**	Indeterminate problem or negative value

* Informational flag only
** Data sent to EMSL-LV for confirmation

END
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